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WHITE RIVER SHALE PROJECT

DETAILED DEVELOPMENT PLAN

FEDERAL LEASE TRACTS U-a & U-b

Volume 1

Part 1: Introduction
Part 2: Description of Project Area
Part 3: Description of Proposed Plan

Copy No. 6

ILLUSTRATIONS

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Section 1.1

Section 1.1

WHITE RIVER SHALE PROJECT POSITION STATEMENT ON OIL SHALE DEVELOPMENT

The White River Shale Project was formed in June 1974 by Phillips Petroleum Company and Sunoco Energy Development Co., the owners of Federal Oil Shale Lease U-a, and Sohio Petroleum Company, the owner of Federal Oil Shale Lease U-b. The project was formed for the express purpose of establishing a plan for joint development of the leases.

In the ensuing time period, as the project team proceeded with carrying out its charge, some very significant external events occurred, and some internal conclusions were reached, which impact seriously on the development of an oil shale industry. Some of the most significant problems currently associated with the commercialization of oil shale are:

- In the last two years, a period of devastating inflation, the estimated cost to construct a 100,000 barrels per day shale oil plant has escalated from the 600 million dollar range to over one and one-half billion dollars, (See Table 1.1-1). The latter cost has been verified in a detailed study carried out for the White River Shale Project by one of the country's leading contractors.
- As a consequence of the sharp increase in capital requirements, the projected price of shale oil required to yield a 15 percent return on investment (1975 dollars) exceeds $20 per barrel on a 100 percent equity investment basis (See Table 1.1-1).
- The present stage of retort technology is not adequate to allow for proceeding directly into commercial development
- A commercial oil shale installation will consist of very large and complex units of mining, retorting,

and upgrading — all close-coupled and interdependent. A high operational risk is involved since each operating unit must have a high availability, or "on-stream" factor, to maintain the desired production levels. Failure to achieve this availability has a disastrous effect on project economic viability.

- There is a great deal of uncertainty and risk relative to environmental issues and political issues. The measures and costs associated with providing an environmentally acceptable facility are difficult to predict in the present stage of development. On the political side, one area of greatest concern is the situation where product prices could be subject to

Table 1.1-1

ESTIMATE OF WHITE RIVER SHALE PROJECT CAPITAL AND OPERATING COSTS[a] (Millions of 1975 $)

Phase	Capital Costs, Million $	Million $/yr	Shale Oil Produced, BPCD
Pre-Phase I	$ 87.5	—	0
Phase I — Mine Opening	4.0	$ 0.5	0
Phase II — Single Retort Operation	136.3	$ 12.4	≈ 5,000
Phases III and IV — Commercial Operation	$1,382.4	$122.6	100,000
Total Capital Costs	$1,610.2		
Estimated Sales Price of Upgraded Shale Oil[b]			$20.00/bbl

(a) Capital estimates based on conceptual design of the "Most Probable Plan" of oil shale development as described in the Detailed Development Plan for Federal Tracts U-a and U-b.

(b) Price estimate based on:

- 100% equity financing
- 15% return on equity
- 1975 dollars — no escalation
- FOB Casper, Wyoming
- No community financing
- 20-year commercial life at 100,000 BPD

some form of control while ever-increasing expenses are not. Also, there is no assurance that the political actions needed to make oil shale development commercially attractive will occur by the time the technological uncertainties have been eliminated.

Notwithstanding all of the aforementioned problems, the White River Shale Project firmly believes that from our national interest viewpoint, a program for oil shale development should be carried to the point that the major technical and economic uncertainties are resolved. We are recommending the following programs for the development of oil shale:

- Demonstration Modules Should be Built

  As a first step, a program should be created that insures demonstration of a wide range of technologies for shale processing. A carefully considered number of modules should be built. These modules would allow for demonstration and evaluation of the technology using full commercial-scale equipment. The module would most probably be a single retort coupled with attendant mining and other required supportive facilities. The demonstration phase will provide a sound base for predicting capital, environmental, and operational costs for an expanded commercial facility.

- Modules will Require Joint Government-Industry Funding

  Our studies indicate that construction and operation of a module will cost in the 100-200 million dollar range and will be unprofitable. In light of the technical and economic uncertainties, this cost level precludes the possibility of demonstrating a wide range of technologies sponsored entirely by private industry. We believe the most realistic approach would be joint government-industry funding through the technology development phase. A basis for industry to acquire the government's interest in the plant should exist. If the technology is successfully demonstrated and if economic conditions permit, the plant could then become the core for an expanded commercial venture.

- Subsequent Commercialization May Require Government Support

  Synthetic fuels cannot be competitive in today's price-regulated market (or at today's world market prices), and there is no assurance whether or when free-market

pricing conditions will again exist. In addition, it is likely that some form of government support may be required to make shale commercialization financeable and competitive in the energy market. Until the modular demonstration phase is completed and a firm evaluation of the economics can be made in the light of the economic environment at that time, we are unwilling to speculate now on either the nature or magnitude of government support that might be required.

- Financial Assistance for Communities

  When conditions for commercialization do occur, it is essential that government assistance should also be available for the communities that will be impacted by the construction of the commercial oil shale plants.

In summary, we are willing to continue our efforts to develop oil shale to meet the country's future energy demand. We are willing to demonstrate jointly with the government what this will require in terms of technology and money. The White River Shale Project intends to submit a proposal to the government for joint industry-government development through the modular stage.

A very poor utilization of the resource would be to proceed directly to construction of a commercial facility which, based on the present state of knowledge, might well be environmentally, technically, and economically unacceptable. Information gained from the modular approach can be expected to suggest modifications to mining, retorting, and environmental protection techniques that would increase the ultimate recovery of shale oil from the ore and thereby contribute to the overall conservation of the resource.

White River Shale Project intends to request a suspension of the lease terms in order to allow time for establishment of a joint industry-government program for the module stage. As is the case in most research and development programs, the modular developmental operation costs will exceed the generated revenues. Therefore, the funding

for this stage should not require loan pay-back but rather incorporate a mechanism for future buy-back of Government interests on an agreed basis from subsequent commercial plant profits.

In addition, the White River Shale Project must have assurance from the government prior to payment of the discretionary fourth and fifth bonus payments that ownership of the Federal tracts can be retained by the lessees until such time that economic and political conditions will permit prudent development of the tracts to commercial capacity, or until the initial term of the lease has expired.

Satisfactory resolutions must be found for the problems cited in this Position Statement, and the project must be economically viable before the White River Shale Project can proceed with lease development as described in this Detailed Development Plan.

Section 1.2

Section 1.2

CONTENTS OF THE DETAILED DEVELOPMENT PLAN

In accordance with Section 10 of the Oil Shale Lease (Ref. 1), the White River Shale Project (WRSP) is required to compose a Detailed Development Plan (DDP) for Tracts U-a and U-b located in northeast Utah adjacent to the White River. The plan must include "a schedule of the planning, exploratory, development, production, processing, and reclamation operations and all other activities to be conducted." In addition, submission of a description drawn in detail is necessary "to assure that the development plan, and lease operations thereunder, will meet and conform to the environmental criteria and controls incorporated in the lease." The lease in effect requires that the DDP conform to all federal, state, and local regulations and standards for air, water, and land quality and that it include environmental safeguards and lease land rehabilitation. The DDP must be approved by the Mining Supervisor before work is begun.

The most probable plan for commercial shale oil production and processing includes mining and retorting followed by crude oil hydrotreating as the principal process to produce oil from the shale. A gross yield of 107,560 barrels per calendar day (BPCD) of shale oil is estimated from Tracts U-a and U-b at full commercial operation.

The DDP for the White River Shale Project is divided into seven basic parts and presented in two volumes:

Volume One

Part 1 — Introduction and General Provisions of the Plan

Part 2 — Description of the Project Area

Part 3 — Description of the Proposed Action

Volume Two

Part 4 — Planned Environmental Protection Procedures

Part 5 — Environmental Effects of the Proposed Action After Mitigation

Part 6 — Monitoring Program

Part 7 — Alternatives and Selection Rationale

For convenience, sections are numbered by part; thus, in Part 3, for example, sections are numbered 3.1, 3.2, 3.3, etc. Following a similar scheme, pages are numbered by part and section; in Section 4 of Part 3, for example, pages are numbered 3.4-1, 3.4-2, 3.4-3, etc. Figures and tables are also numbered by part and section.

The general outline of the DDP appears as the Table of Contents and is found at the beginning of each volume. Each of the seven parts is described briefly below:

- Introduction and General Provisions of the Plan. Part 1 presents a general outline of the DDP, sets forth the objectives of the oil shale prototype program, discusses issuance of the leases for Tracts U-a and U-b, describes the White River Shale Project, and briefly recounts exploration and baseline data collection.
- Description of the Project Area. Part 2 is a condensation of the first-year baseline data report, a 12-month environmental survey and analysis prepared for WRSP by VTN of Denver, Colorado.
- Description of the Proposed Action. Part 3 describes the most probable plan for the project from its inception through all of its development and operation activities to the conclusion of decommissioning or abandonment.

- Planned Environmental Protection Procedures. Part 4 presents the procedures proposed for mitigation of adverse environmental effects incurred by implementation of the most probable plan.
- Environmental Effects of the Proposed Action After Mitigation. Part 5 sets forth the net environmental effects that may be expected by implementation of the most probable plan, as described in Part 3 and as modified by the protection procedures described in Part 4.
- Monitoring Program. Part 6 advances the required environmental monitoring program that is, in part, an extension of the baseline monitoring program. Other effects that will occur during the program will be monitored to ascertain that controls are adequate.
- Alternatives and Selection Rationale. Part 7 describes various alternatives to the plan in Part 3 and outlines the reasons for choosing the most probable plan.

A glossary and a complete list of references are also included in both volumes.

Section 1.3

Section 1.3

THE OIL SHALE PROTOTYPE PROGRAM

In June 1971, the Secretary of the Interior announced plans for a proposed oil shale development program. At that time he released a preliminary environmental statement (Ref. 2), a program statement (Ref. 3), and reports prepared by the states of Colorado, Utah (Ref. 4), and Wyoming on environmental costs and problems of oil shale development. These actions followed President Nixon's energy message in which he asked the Secretary of the Interior to initiate a "leasing program to develop our vast oil shale resources, provided that environmental questions can be satisfactorily resolved."

The resulting prototype program is designed to develop U.S. oil shale resources by the following plan of action:

- Develop mining and retorting technology for oil shale production
- Stimulate private industry to produce commercial quantities of oil from shale
- Ensure that the environmental integrity of the area is maintained to the greatest degree possible
- Develop methods and technology for protection of the environment
- Permit an equitable economic return for all parties
- Develop leasing management expertise for oil shale production

The Department requested nominations in November 1971 of proposed tracts for lease, and 20 individual tracts of oil shale land were nominated.

In April 1972, with the concurrence of the states concerned, the Department of the Interior announced the selection of six of these tracts: two each in Colorado, Utah, and Wyoming.

The program is essentially unchanged from that announced in June 1971, but the preliminary statement issued at that time was expanded to consider the impact of mature oil shale development, to examine the impact of developing the six specific tracts, and to include a comprehensive analysis of energy alternatives.

The draft of the Final Environmental Statement was released by the Department of the Interior to the public in September 1972. Subsequent public review, ending in November 1972, provided important information for expanding and correcting the draft material, where appropriate. The Final Environmental Statement for the Prototype Oil Shale Leasing Program was issued in August of 1973 (Ref. 5). That document is based on information from many sources, including research data and pilot programs developed by both the government and private industry over the past 30 years. Many factors — such as changing technology, eventual oil production levels, and attendant regional population increases — are not precisely predictable; therefore, the impact analysis is regarded only as a reasonable treatment of the potential regional and specific environmental effects associated with oil shale development.

To assist and advise the Department of the Interior about environmental matters connected with the operation of oil shale leases, an Oil Shale Environmental Advisory Panel (OSEAP) was established by the Secretary of the Interior in accordance with the provisions of the Federal Advisory Committee Act, Public Law 92-463 (Ref. 6). The OSEAP is composed of members appointed from bureaus within the Department and from other interested federal agencies, of members representing state and local governments, and of members of the general public active in environmental

matters. The function of the panel is to advise the District Manager of the Bureau of Land Management, the Mining Supervisor of the Geological Survey, and any other officers or employees of the Department promptly about environmental matters involving the exercise of their respective responsibilities under the prototype oil shale leasing program.

Section 1.4

Section 1.4

LEASE ISSUANCE AND PROVISIONS

1.4.1 LEASE HISTORY

The Federal Oil Shale Leasing Program was created in response to President Nixon's 1971 request to the Department of the Interior for a method of developing the extensive oil shale resources of the country. The initial action was nomination of tracts of land for lease. The six tracts selected — two each in Colorado, Utah, and Wyoming — are all in the rich Green River Formation where oil yield may average 30 gallons per ton of shale. Competitive bidding on the six tracts took place from January to June of 1974. Bids were received and accepted on both tracts in Utah and in Colorado; no bids were made on the Wyoming lands.

Both of the Utah leases went into effect on June 1, 1974. Tract U-a was leased by Phillips Petroleum Company and Sun Oil Company. Tract U-b was originally leased by the White River Shale Oil Corporation (comprising Phillips Petroleum Company, Sunoco Energy Development Company, and Sohio Petroleum Company) but the tract has since been fully assigned to Sohio Petroleum Company.

1.4.2 LEASE PROVISIONS

The chief constraints and provisos of the two leases (which are essentially identical) are described briefly in the following paragraphs. The details can be found in Federal Leases 25918 and 26194 (Ref. 1).

1.4.2.1 Terms

Leases will run for 20 years and can be renewed as long as commercial quantities of oil are being produced in accordance with lease terms. The terms of the lease can be renegotiated at intervals of 20 years.

1.4.2.2 Bids and Bonuses

Leases were awarded on the basis of bonus payments for lease rights to individual tracts, a tract being awarded to the bidder offering the highest bonus. One-fifth of the total bonus payment accompanied the bid offer; the remainder is due in four equal annual payments, the fourth and fifth of which are optional.

1.4.2.3 Rentals

A rental fee of 50 cents per acre per year will be charged before production begins; however, rental payments (due at the beginning of a year) may be credited against royalty payments (due at the end of a year). Each lease covers approximately 5,120 acres.

1.4.2.4 Royalties

A royalty payment, computed at 12 cents per ton for oil shale containing 30 gallons of shale oil per ton, will be levied. The royalty rate will be computed according to the oil content of the shale. Royalty payments may also be adjusted on an annual basis to reflect changes in the prices of crude oil.

1.4.2.5 Minimum Royalty

A total minimum royalty of $5.5 million will be charged over 20 years, the minimum royalty being based on the formula explained in Section 7(e) of the lease (Ref. 1).

1.4.2.6 Royalty Reduction

Production before the eighth anniversary of the lease will earn a reduction of royalty amounting to half of the difference between minimum and actual royalty.

1.4.2.7 Credits

Certain expenditures can be credited against the last two bonus payments and minimum royalty requirements. Unanticipated environmental costs incurred between the sixth and tenth anniversaries of the lease may be credited against production royalty payments, if the Secretary of the Interior deems it desirable.

1.4.2.8 Diligency Requirements

Before the third anniversary of the granting of the lease, each lessee must submit a detailed development plan for approval by the Area Oil Shale Mining Supervisor (AOSS). If the development plan submitted is not acceptable, the Mining Supervisor will issue up to two written notices explaining to the lessee why the plan is unacceptable. If the lessee fails to submit an acceptable plan within 1 year after the second notice, the lease may be cancelled.

1.4.2.9 Environmental Baseline Data

Environmental baseline data pertaining to the quantity and quality of surface water and groundwater, the quality of the air, and the population relationships of flora and fauna must be collected for at least 1 year before submission of a detailed development plan and for an additional year before commercial operations.

1.4.2.10 Environmental Monitoring

The lessee must conduct environmental monitoring programs before, during, and after oil shale development operations. The results of this monitoring will be submitted to the AOSS, as required by him, and released periodically to the public.

1.4.2.11 Public Hearings

The Mining Supervisor will conduct public hearings on environmental aspects of the Detailed Development Plan. He will be assisted by OSEAP, which is composed of members from the Department of the Interior and other federal agencies, state and local governments, and the private sector.

1.4.2.12 Mitigation

The Detailed Development Plan must show compliance with all federal, state, and local regulations and standards governing air, water, land, and fish and wildlife management; this plan must be approved by the Mining Supervisor before development is started. The lessee is responsible for rehabilitating all disturbed areas. The Department of the Interior will require a revegetation research program unless the lessee can prove availability of technology to fulfill the requirements of the program.

The proposed mitigation programs are detailed in Part 4 of this DDP. The main areas of concern addressed are as follows:

- Air pollution
- Solid waste disposal
- Water pollution
- Water drainage and erosion
- Surface rehabilitation
- Fish and wildlife description
- Protection of historic, prehistoric, and paleontological resources
- Preservation of aesthetic values
- Fire protection
- Contingency plan for oil and hazardous materials spill
- Protection of public health and safety

Section 1.5

Section 1.5

THE WHITE RIVER SHALE PROJECT

The White River Shale Project provides for the development of oil shale resources on federal lease Tracts U-a and U-b in northeastern Utah. At the present time, the White River plan regarded as most probable among many alternatives calls for staged development of mining, processing, and related operations in four phases.

The first phase of the most probable plan includes sinking an access shaft for initial testing and examination of the ore body.

The second phase of the most probable plan comprises mining and retorting designed to generate specific information on ore body characteristics that cannot be determined by core drilling. This operation, in which 2,000 to 10,000 tons per calendar day (TPCD) of shale will be mined, will permit selection of those techniques best suited to producing oil from the specific shale mined from U-a and U-b in a larger scale program and in a manner that is environmentally sound.

The third and fourth phases of the White River most probable plan cover the growth of shale oil production to a full-scale level of 50,000 to 100,000 barrels per calendar day (BPCD) and through operation to exhaustion of resources. This plan includes the support facilities needed at each stage of development and deals with water, power, and access requirements.

The most probable plan outlined above is intended only to represent the case where conditions prevail at the appropriate time in the plan so that positive, good business decisions can be made. Nothing in this plan

should be construed to mean that alternative courses could not be pursued, including exercising the option to relinquish the leases at any time subsequent to payment of the third lease bonus.

1.5.1 PROJECT ORGANIZATION

The White River Shale Project contemplates joint development of federal lease Tracts U-a and U-b, and this DDP has been prepared on that basis. Tract U-a is leased by:

- Phillips Petroleum Company
  781 Frank Phillips Building
  Bartlesville, Oklahoma 74004
- Sunoco Energy Development Company
  12700 Park Central Place
  Dallas, Texas 75251

Tract U-b is leased by:

- Sohio Petroleum Company
  300 Enterprise Building
  3rd and Main Streets
  Grand Junction, Colorado 81501

1.5.2 TRACTS U-a AND U-b

Maps and more detailed descriptions of Tracts U-a and U-b are found in Part 2 of this DDP and the supporting document, First Year Environmental Baseline Report, White River Shale Project (Ref. 7).

1.5.2.1 Location and Description

Tracts U-a and U-b, located in a remote part of northeastern Utah, lie immediately south of the White River in the eastern part of the Uinta Basin. A map showing the location of the two tracts in this area is presented in Figure 1.5-1. The nearest community is Bonanza, about 10 miles away with a population of approximately 20; the nearest town in

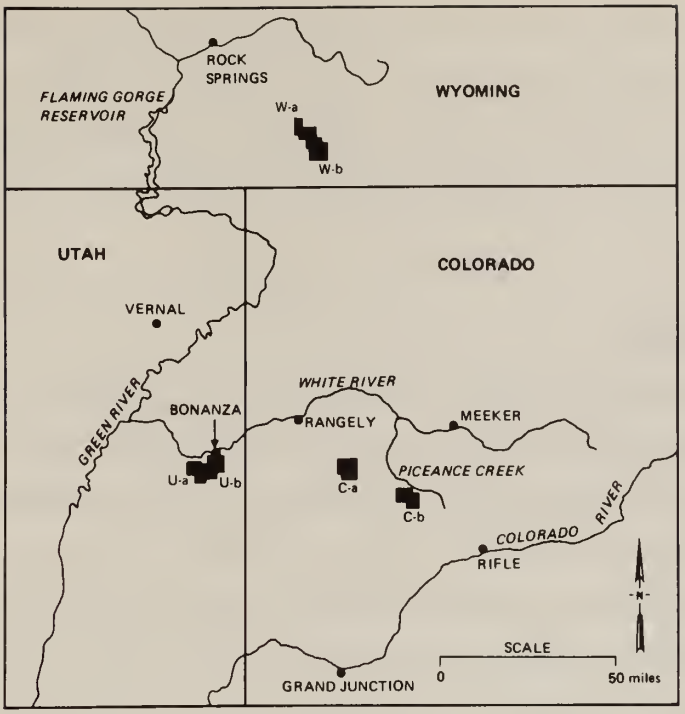


Figure 1.5-1. Location of Tracts U-a and U-b

Utah having a full range of services is Vernal, population approximately 6,000; and the nearest town in western Colorado is Rangely, about 30 miles away. Vernal is served by U.S. Route 40 and Bonanza by Utah Route 45. From Bonanza, the tracts and the proposed process areas can be reached by dirt roads that are not a part of the state system.

The only perennial stream in the area is the White River, whose valley occupies a narrow strip about 800 feet wide at the northern edge of Tracts U-a and U-b. Southam Canyon, a slightly meandering drainage, extends northwestward across Tract U-a and joins the White River just outside the tract. The canyon of Evacuation Creek trends northward across the central part of Tract U-b. West of Evacuation Creek, the terrain is more rugged and is characterized by ledges and cliffs along the canyon walls and numerous buttes along the drainage divides. Ground cover in both tracts is sparse, consisting mostly of shrubs. Altitudes

within the tracts range from 4,900 feet at White River to approximately 5,960 feet in the south-central part of Tract U-a. The greatest altitude difference in a short distance is about 450 feet in 1/2 mile in the south-central part of Tract U-a. These general terrain features are identified in Figure 2.2-2.

1.5.2.2 Geology

The Uinta Basin is a sedimentary, structural, and topographic basin. Oil shale of the Green River Formation is exposed along the south and east margins of the basin, and is concealed by younger sediments in the central and northern parts of the basin. Available drilling information indicates that the thickest, richest oil shale is in the eastern half of the basin, mostly concealed by younger rocks of the Uinta Formation. Geologic maps and description of the oil shale in the southeastern part of the Uinta Basin are shown by Cashion's USGS Professional Paper 548 (Ref. 8).

Conformably underlying the Uinta Formation is the Green River Formation composed of the Parachute Creek Member and the older Douglas Creek Member. The Parachute Creek Member is of major interest because it contains the rich oil shale sequence known as the Mahogany zone.

The Parachute Creek Member consists of finely laminated siltstones, marlstones, and oil shales with numerous thin tuff beds, deposited in a deep-water lacustrine environment. Oil shale is commonly defined as kerogen-rich marlstone that will yield more than 15 gallons of oil per ton. Within the Parachute Creek Member, the 100-foot thick Mahogany zone occurs approximately 500 feet below the top of the member (Ref. 2). Approximately 40 feet below the top of the Mahogany zone, the 10-foot thick Mahogany bed occurs; it is the richest bed of oil shale. Part of the Mahogany zone, including the Mahogany bed, is the prime target for underground mining.

1.5.2.3 Mineral Resources

Tract U-a. Assayed samples from Tract U-a show an average thickness of approximately 55 feet for oil shale with an average yield of 28 gallons of shale oil per ton. Overburden above the Mahogany zone ranges from 550 to 1,225 feet; the average is approximately 850 feet. The shale oil resource present in the Mahogany zone is estimated to be 540 million barrels (Ref. 5). Current estimates anticipate that 70 percent of these reserves can be recovered by underground mining methods. Nahcolite is present in the tract only as very thin lenses and small pods. No significant amounts of bituminous sandstone are reported in Tract U-a.

Four deep gas wells were previously drilled on the tract. Three were abandoned, and one remains capped. This shut-in well flowed at 11,000 cubic feet per day from a zone 3,300 feet below surface. A commercial gas reserve is not anticipated under Tracts U-a and U-b.

Tract U-b. Assayed samples from core holes in Tract U-b also show that the rich vein of shale averages 55 feet in thickness. Overburden above the principal oil shale beds ranges from 300 to 1,250 feet, and the average is about 700 feet. The shale oil resource on the tract is estimated to be about 510 million barrels (Ref. 5), 70 percent of which should be recoverable by underground mining. Nahcolite occurs as very thin lenses or beds and small pods in the upper part of the Green River Formation. No commercial oil or gas has been discovered on this tract, and no significant amount of bitumen is known to occur in the sandstone. One narrow Gilsonite vein, less than 2 inches wide, was reported in the United States Geological Survey Publication No. 548 (Ref. 8) in the west-central part of the tracts.

1.5.2.4 Water Resources

Tracts U-a and U-b are close to the White River, and water is available for use. Mean flow of the White River in this reach is approximately

700 cubic feet per second, and the weighted average-dissolved-solids concentration is approximately 400 milligrams per liter. Water could also be obtained from the Green River and from the Flaming Gorge Reservoir by diverting and pumping at a point on the Green River about 30 miles from the tracts.

Groundwater occurs in the Bird's Nest Aquifer above the oil shale, but data indicate that the yields are generally small. The groundwater supply does not appear to be large enough to provide a significant supply of water for operations at U-a and U-b.

1.5.2.5 Climate and Air Resources

The climate of both Tracts U-a and U-b is semiarid. Annual precipitation ranges from approximately 8 inches at lower elevations to 10 inches over higher terrain, with about 4 inches from May to September, mostly from thunderstorms, and 6 inches from October to April. Approximately 25 days per year have more than 0.01 inch of precipitation. Severe local thunderstorms in summer may cause strong gusty winds and local flash flooding. The average annual snow accumulation is about 10 inches, but open areas may remain free of snow for most of the winter.

The area has dry hot summers, with an average July maximum temperature of 95°F, an extreme of 105°F, and an average July mean of 75°F. The winters are relatively dry and cold. The average minimum for January is 8°F, the extreme minimum recorded is -25°F, and the average January mean is 20°F. The frost-free period is approximately 110 days.

Surface airflow on the tracts is complicated by rough terrain effects. During the early morning hours, air flows generally along drainage channels toward low terrain and along the White River. In the afternoon, winds are stronger and less variable, flowing generally from the west or southwest.

Air quality on the tracts, with few exceptions, has consistenly been very good, as is expected for a remote location.

1.5.2.6 Biological Resources

The biota on and near the tracts are typical of sparse desert shrub community; that is, vegetative cover of the region is, for the most part, shrub-dominated. Given the preponderance of salt-tolerant shrubs, the vegetation should be designated as a salt desert shrub type. Trees dominate the riparian areas and the higher elevations at the southern edge of the tracts.

Sheep graze on the tracts in winter and early spring, and some cattle graze in riparian areas in spring and summer. The greatest impact on the area arises from sheep being driven across the eastern portion of Tract U-b.

From late summer to early winter, mule deer can be found in the White River riparian habitat and adjacent areas. The tract area is occasionally used for hunting. The only small-game species on the tracts is the cottontail rabbit. Sixteen species of rodents and six species of carnivores have been observed; porcupines are found in riparian habitats, and coyotes, raccoons, skunks, bobcats, and badgers are found on the tracts.

The tracts support a breeding population of mourning doves, and there is a small breeding population of Canada geese along the White River. Other species of game bird are uncommon or occur as spring transients. Thirteen species of raptors have been observed on or near the tracts, and 82 bird species other than game birds and raptors have been observed.

Reptiles occur in all four vegetation communities in the White River region. Six species of lizards and five species of snakes have been observed on the tracts.

Approximately 1,500 species of insects have been collected on or near the tracts.

1.5.2.7 Historical Resources

Before the white man came, the Uinta Basin was primarily the homeland of the Ute Indians. The first European contacts were with Spanish explorers and traders from the South. The first year-round white settlement was a trading post established at Fort Rubidoux in 1838. The colonization of the area by Mormon settlers in the latter decades of the 19th century greatly influenced the shaping of the present economy and culture of the Uinta Basin. Although the Wasatch Front was settled earlier, the first Mormons did not enter and explore the Uinta Basin until 1861. The agrarian settlers and the Ute inhabitants were in direct competition for the limited resources available, and an extended period of recurring hostilities ended with the transfer of Utes to the Uinta and Uncompahgne Reservations in 1881.

Another important influence on the evolution of the Uinta Basin was the discovery and extraction of the area's rich mineral resources, particularly the discovery of Gilsonite in the late 1800's. Gilsonite mining grew rapidly and hastened the development of the area.

The most important historic feature on or near Tracts U-a and U-b is the Ignatio Stage Station on the White River, north of Tract U-b. This site, one of a series of stage stops along the Uintah Railway toll road that connected the rail line to Vernal, has been nominated for inclusion on the National Register of Historic Sites; if registered it will be protected by special regulations and will be eligible for federal funding for preservation or restoration purposes. Although the remaining structures at the site are in poor condition, they are a good example of late frontier architecture in this part of the county.

1.5.3 PROJECT DEVELOPMENT

A project schedule for the White River Shale Project (WRSP) is presented in Figure 1.5-2, and a brief description of the project follows. A more detailed description of the items shown on the schedule is found in Part 3 of this DDP.

1.5.3.1 Preliminary Planning

Early planning was contained in a Preliminary Development Plan (PDP) (Ref. 9) submitted in April 1974 in accordance with the Department of Interior's prototype oil shale leasing program and with instructions published by the Department of Interior in the Federal Register of November 30, 1973 (Ref. 10). It is important to note that this early plan was a preliminary plan to be modified as additional data and information became available. At that time, the lessee intended to discuss in a general way the development of Tracts U-a and U-b realizing that a great deal of additional information was needed to prepare the present plans, which are disclosed in this Detailed Development Plan.

1.5.3.2 Exploratory and Baseline Activities

Exploration, coring, and environmental baseline activities were initiated on the tract and plant site area in the summer and fall of 1974. The primary objective of these activities was to develop and install various monitoring stations for baseline data collection. Test wells were drilled and surveyed, and air and water monitoring stations were placed in operation before the winter season (1974-75). The preliminary activity on the tract was governed by the lease and CFR Title 43 Part 23, and Title 30 (Ref. 11) concerning surface exploration, mining, and reclamation of public lands.

1.5.3.3 Initial Mine Access and Single Retort Operation Phases

The WRSP will start with sinking an access mine shaft and developing a room and pillar mining operation, followed, in accordance with the schedule, by enlarging this mining operation and installing a single vertical retort suitable for processing shale. The objectives of the initial mine access and single retort operation phases are as follows:

- To initiate a significant level of mining activity on Tracts U-a and U-b to determine characteristics of the shale with respect to rock mechanics, gas content, retorting and crushing characteristics, and other commercial operation factors
- To prove commercial-sized vertical retorting through operation of one large-scale unit
- To ascertain the quantities and qualities of the raw shale oil and gas under varying conditions, and to project the design of equipment to handle the material
- To ascertain production costs at near-commercial scale to define the economics of producing shale oil
- To determine accurately the environmental effects of operating the commercial demonstration facilities, and means of mitigating and controlling adverse effects
- To begin these operations with an orderly development of facilities, personnel, and actions designed to fit into and become part of the future commercial-size facility as far as practicable

1.5.3.4 Facilities Engineering and Construction

Successful initiation and operation of the single retort installation will be followed by engineering and construction of a commercial plant in accordance with the above schedule. Development is planned in two steps, each involving up to 50,000 BPCD output capacity.

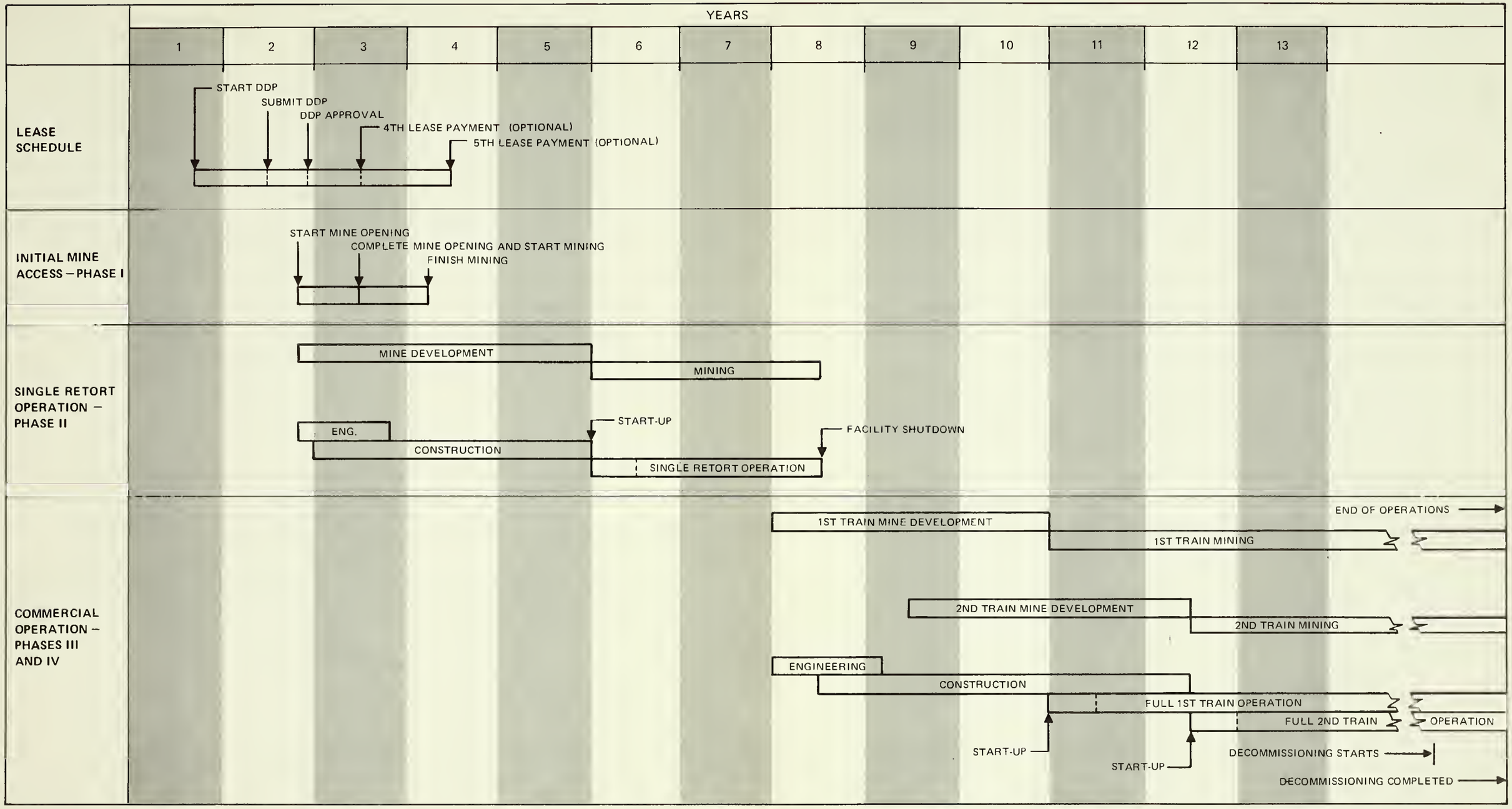


Figure 1.5-2. Most Probable Plan – Schedule of Facility Development

1.5.3.5 Production and Processing

The most probable scheme for commercial shale oil production and processing comprises mining and retorting followed by crude shale oil hydrotreating as the principal process to produce an upgraded shale oil. Probable by-products will be sulfur and ammonia. For the purposes of this report, the commercial shale oil facility has been sized at 100,000 BPCD.

For the commercial plant of approximately 100,000 BPCD, mining operations will produce about 160,000 TPCD of raw shale. The mine will employ proven room and pillar techniques, modified as necessary on the basis of the experience gained during the single-retort operation. First mining will recover some 70 percent of the in-place ore. The raw shale will be prepared as retort feed by several stages of crushing and screening, with primary crushing carried out in the mine. The coarse-crushed raw shale will be lifted to the surface, where it will undergo secondary crushing and be reduced to an appropriate size for retorting. A stockpile of primary-crushed raw shale will be maintained to ensure steady operations.

The bulk of the raw shale from secondary crushing will be processed in vertical retorts, with direct-heated (DH) and indirect-heated (IH) retorts being used to achieve the gas quantity and composition required by subsequent upgrading operations and by the process heat balance. The remainder of the crushed raw shale will be processed in fines-type retorts.

The crushed raw shale will be fed to the retorts by covered conveyors, which will also transport the processed shale to Southam Canyon for disposition. In Southam Canyon, the processed shale will be placed in accordance with a program designed to permit handling these very large quantities of material in a manner that is structurally, environmentally, and economically sound.

The 100,000 BPCD of crude shale oil from retorting will be processed in two parallel hydrotreating units, together with additional naphtha hydrotreatment, for a gross yield of 107,560 BPCD of C_5^+ upgraded shale oil. To satisfy the facility fuel requirement, some upgraded shale oil will be used as process and utility plant fuel as follows:

	BPCD
Diesel fuel (400°F to 600°F TBP)	1,080
Process fuel oil (400°F+ TBP)	7,710
Utility plant fuel oil (400°F+ TBP)	2,770
Total	11,560

Thus, the net upgraded shale oil product from the facility will be 96,000 BPCD.

Supporting process facilities will consist of light-ends compression, hydrogen production, amine gas treating, sulfur recovery and tail gas treating, wastewater treating, and sour water stripping. Supporting offsite facilities will consist of storage, product movement, relief and blowdown, utilities, water supply, wastewater treatment, solid waste handling, and maintenance and administrative facilities.

Sulfur and ammonia produced from the facility will amount to 165 and 412 TPCD, respectively.

The upgraded shale oil from the oil shale facility has the following approximate properties:

Product quantity	96,000 BPCD
Pour point	50°F
Gravity	40.0° API
Viscosity @ 40°F/100°F	13 CS/4 CS
Sulfur content	0.025 wt %
Nitrogen content	0.034 wt %

Since the upgraded shale oil pour point exceeds the 35°F specification for shipping in a pipeline, addition of a suitable pour point depressant may be required.

The properties of the upgraded shale oil are based on existing pipeline and processing constraints typical of the industry. A lower quality oil product may be acceptable, depending on marketing opportunities.

1.5.3.6 Support Facilities

During the early single retort operation phase of the WRSP, electric power may be purchased from Moon Lake Electric Association, Inc. Moon Lake operates a power line near Tracts U-a and U-b that is adequate to supply the quantities of power required during this early period. For the construction period of the full-scale plant and the operation of the first-train and two-train commercial units at 50,000 and 100,000 BPCD, Moon Lake will continue to be a power source, but not responsible for supplying the bulk of the power required for the project. Most of the power will be generated on site by burning scrubbed process offgas.

During the single retort operation phase, water will be taken from the White River. Water will be drawn from wells located at the river bank and pumped to the plant site by pumps mounted on tract. For the full-scale operation, water will be purchased from a supply available from a dam on the White River; a pump station about 500 feet from the water's edge will raise the required quantity of water from river level to the project site as needed.

Crude shale oil product, and any other by-products generated, will be transported by truck during the single retort operation phase. The quantity of oil produced (approximately 5,000 BPCD) is suitable for

movement by truck. During full-scale operation at either 50,000 or 100,000 BPCD, the oil will be transported by pipeline. In the most probable plan, the oil will be moved by pipeline to Casper, Wyoming, at which point the pipeline will join common carrier pipelines to permit transport and distribution of shale oil as required.

Section 1.6

Section 1.6

EXPLORATION AND BASELINE DATA COLLECTION

1.6.1 EXPLORATION PROGRAM

The partial exploratory plan submitted by Sun Oil Company and Phillips Petroleum Company for Tract U-a (Ref. 14) and by the White River Shale Oil Corporation for Tract U-b (Ref. 15) covered the next phase of the exploratory drilling program. The lessees drilled nine core holes on Tracts U-a and U-b to supplement the initial seven holes drilled as part of the tract nomination program, plus the four pilot test holes for the groundwater hydrology program.

The core drilling program provided for an approximate 1-mile spacing of holes for this phase of the program. Additional core hole locations will be proposed for approval if further geologic and structural information is required for mine design.

The objectives of the proposed program were to:

- Determine oil shale grade throughout the tracts
- Determine whether major fault offsets occur in the oil shale mining zone
- Determine the principal partings, joints, and fracture systems in the oil shale mining zone and their continuity within the tracts
- Determine structural attitude of the strata
- Provide core samples for strength-of-materials testing for initial mine planning and design
- Provide additional subsurface hydrologic data

A total of 20 vertical core holes has been drilled on the two tracts and has resulted in recovering some 9,000 feet of core. Nearly 6,200 Fischer assays, representing 7,200 feet of core, have been completed. An additional 5 core tests, 3 vertical and 2 inclined, are being drilled at the time of this writing (March 1976).

Drill cuttings were collected at 10-foot intervals except for cored intervals. Oil yield assays were run on 1-foot increments of the core using the modified Fischer retort method. Analyses for nahcolite were run where this mineral was identified in the core. No Dawsonite was identified in the core. Other mineralogical and trace element analyses were run on the raw and processed shale samples as required. Portions of the recovered core were also used for physical testing. The Fischer assay spent shale from 13 of the core tests was assayed for extractable alumina. In none of these core tests did alumina average as much as 0.5 percent over the proposed mining interval.

The rock mechanics evaluation of the physical characteristics of the ground mass immediately above and below the economic oil shale zone, and also within the zone, will provide design criteria for underground mine development. Test specimens were taken from the core at 10-foot intervals, starting 50 feet above the ore zone and continuing to 50 feet below the ore zone. At each test interval, sufficient core samples were taken to allow for the preparation of two test specimens; one specimen from each interval was tested to destruction, one was preserved for further testing at a future date.

1.6.2 BASELINE DATA COLLECTION

Initial data collection for the first-year environmental baseline survey, begun in the fall of 1974 in accordance with lease stipulations, has been completed. Data were compiled in the areas of water resources, air

resources, biological resources (terrestrial and aquatic), geologic exploration, and aesthetics. This program, along with the second-year environmental baseline data collection and monitoring program, is being conducted in accordance with the Partial Exploration Plan, Environmental Baseline Data Collection and Monitoring Element (Ref. 16) submitted July 1, 1974, and the conditions of approval developed by the AOSS for various subelements of the program. They provide for compliance with all established environmental criteria and will be subject to review as part of the DDP public hearings.

Section 2.1

Section 2.1

INTRODUCTION

In this section, a brief description of the project area is presented, highlighting the resources of the region. The general subjects discussed include the following:

- Geology and Soils (Section 2.2)
- Water Resources (Section 2.3)
- Air Resources (Section 2.4)
- Biological Resources (Section 2.5)
- Historic, Prehistoric, and Paleontological Resources (Section 2.6)
- Aesthetics (Section 2.7)

In Part 5, "Environmental Effects of the Proposed Action," the same subjects will be re-examined to determine the net positive or negative effects of project construction and operation after implementation of the planned environmental protection procedures discussed in Part 4.

This presentation of the setting, both on and around Tracts U-a and U-b, is a condensation of the First Year Environmental Baseline Report, White River Shale Project (FYEBR). Because the intent of this part of the DDP is to offer a succinct narrative description of the general trends observed, the discussion is necessarily brief. Those who are interested in a more detailed technical discussion of the various topics presented, or who are concerned with the statistical validity of the data, are directed to the corresponding section of the FYEBR (Ref. 7). The field study and data processing techniques used for the baseline program are described in detail in the Partial Exploration Plan.

Section 2.2

Section 2.2

GEOLOGY AND SOILS

2.2.1 PHYSIOGRAPHY

Tracts U-a and U-b are located in the eastern portion of the Unita Basin, a broad, asymmetric basin located on the northeastern edge of the Colorado Plateau (Figure 2.2-1). The Uinta Basin overlies alluvial sediments of a prehistoric depositional lake basin. Major land features bordering the basin are the Uinta Mountains on the north, the Wasatch Range on the west, the Roan Cliffs on the south, and the highlands associated with the subsurface Douglas Creek Arch along the eastern edge.

Tracts U-a and U-b are bounded by the White River to the north, Hells Hole Canyon to the east, upland areas of elevations between 6,000 and 6,200 feet to the south, and Asphalt Wash to the west. The region near the tracts, including all the area extending southward to the Roan Cliffs and westward to the Green River, is a gently northsloping, highly dissected plateau, characterized by steep-walled canyons with ephemeral streams or dry washes that are subject to occasional flash floods. The relief of these canyons averages 30 to 50 feet, but in some places is as much as 1,000 feet.

2.2.1.1 Geomorphology

In the southeastern portion of the Uinta Basin, intertributary divides between major drainages are broad and capped by resistant rock strata. These strata dip northwestward a little more steeply than does the

plateau surface itself to create narrow, benchlike mesas, cuestas, and hogbacks. Within Tracts U-a and U-b, the landscape is composed of a series of north- and south-trending valleys separated by narrow, elongated mesas. There are three dominant ridge sections that trend just west of north, north, and just east of north as one proceeds from east to west across Tracts U-a and U-b. The general direction of these landforms is perpendicular to that of the White River.

Physical weathering processes on Tracts U-a and U-b include frost action and mass wasting. Chemical weathering by solution, oxidation, and carbonation is also an important phenomenon. Sheet wash leads to colluvium deposits on slopes and the piling of debris upgradient from vegetation established on slopes. Gully erosion is also prevalent. Large amounts of sediment are picked up by water flowing down Asphalt Wash, Southam Canyon, and Evacuation Creek during occasional high-intensity summer thunderstorms. Erosion of dirt roads that parallel or traverse sections of these channels and their tributaries further contributes to the sediment load.

There is a greater diversity of ground slope gradients on Tract U-a than on Tract U-b, and the slopes found within Tract U-b (Figure 2.2-2) are more gentle. The steepest slopes on the tracts are found adjacent to Evacuation Creek as it flows through Tract U-b, along the northwest-trending ridge that lies in the west portion of Tract U-a, within the southeast corner of Tract U-a, and in the southwest portion of Tract U-b. Channel cutting along the White River has also created steep slopes near the north borders of Tracts U-a and U-b. The most gentle slopes occur on the mesa tops that lie parallel to and along Evacuation Creek, in northern portions of Tract U-b, and in sections of the eastern portions of Tract U-b. Level to gently sloping land is found in the south and southwest portions of Tract U-a.

—·— PHYSIOGRAPHIC BOUNDARY

INDEX MAP

N

8 4 0 8

SCALE IN MILES

Figure 2.2-1. Physiographic Map of the Uinta Basin Region

LEGEND

0-6% (0-3°) :
LEVEL TO GENTLY SLOPING

7-14% (3-6°) :
UNDULATING TO ROLLING

15-30% (7-13°) :
ROLLING TO HILLY

31-50% (14-22°) :
HILLY TO STEEP

≥ 51% (≥23°) :
STEEP AND VERY STEEP

N

2000 0 2000

SCALE IN FEET

Figure 2.2-2. Slope Gradient Map — Tracts U-a and U-b

Geologic structure and erosion have influenced the development of several landforms on Tracts U-a and U-b, especially rock pinnacles and balanced rocks. These numerous and prominent forms occur on or near ridgetops. They have been developed by progressive headward erosion from drainages along vertical fractures or joints. Over long periods this process leaves large isolated blocks of rock standing, whose development is enhanced by the presence of a more resistant caprock. In addition, large rock faces on canyon walls along the White River plainly show evidence of massive rock failures. These rock failures have occurred along vertical fractures that are generally perpendicular to the bedding.

2.2.1.2 Drainage Basin Form and Process

The overall drainage pattern of the Uinta Basin is predominately dendritic, but because of the influence of the northwest-trending and northeast-trending sets of joints in the surficial rock formations, there are many straight reaches along stream channels. Larger streams of the basin have well-developed, meandering channels within their relatively straight, steep-walled flood channels. Level portions of land near the river exhibit a fine-textured drainage density, while upland areas of the Uinta Formation remain relatively undissected. Surficial outcrops of the Parachute Creek Member of the Green River Formation have a higher drainage density than the Uinta Formation.

2.2.2 GEOLOGIC HISTORY

In its early stages of formation, during the Paleocene Epoch, the Uinta Basin was the northeastern portion of a much larger intermontane lake basin that spread over most of the State of Utah. Beginning with the Early Eocene Epoch, Lake Uinta covered the entire Uinta and Piceance Creek Basins and possibly connected with another large lake that covered most of southwestern Wyoming. By the close of the Early Eocene, this lake basin had dried up after accumulating a thick sequence of deep sediments from the surrounding highlands to form the present figuration of the Uinta Basin.

Sequences of strata that crop out in this region reflect the different stages of evolution of the basin. When Lake Uinta existed in its maximum dimensions, the Green River Formation sediments and organic matter accumulated on the lake bottom. As the lake diminished because of further rise of the Uinta Mountains and the Douglas Creek Arch, alluvial sediments of the Uinta Formation were deposited over the surface of the Uinta Basin by meandering streams (Ref. 17).

2.2.3 STRATIGRAPHY

2.2.3.1 Green River Formation

The Green River Formation is an Eocene Series that consists primarily of light-gray to dark-gray, hard, brittle marlstone and oil shale, interbedded with relatively minor amounts of brown sandstone, siltstone, nahcolite nodules, and thin volcanic tuff beds. Total thickness of the formation beneath the tracts is about 1,600 feet. The uppermost portion of the Green River Formation is exposed along Evacuation Creek and in the far northeastern edge of Tract U-b (Figure 2.2-3). Bradley (Ref. 18) described in detail the origin and occurrence of the Green River Formation. More recent work (Ref. 19) has led to a revised subdivision and nomenclature for the members of the Green River Formation. These members are listed and described in ascending stratigraphic order in the following paragraphs:

- Douglas Creek Member. Compared with other parts of the Green River Formation, the Douglas Creek Member consists largely of sandstone and limestone, some marlstone, and only a small amount of oil shale. Outcrops of the Douglas Creek Member in Hells Hole Canyon just east of the tracts and in Evacuation Wash just southeast of the tracts reveal that the member is composed primarily of light-yellowish-brown and light-gray oolitic limestone interbedded with gray-to-brown sandstone and siltstone. As shown in Figures 2.2-4 and 2.2-5, this member is not exposed at the surface within the tracts, but lies

below depths ranging from approximately 1,250 to 1,750 feet. Maximum thickness attained by this member, beneath the tracts, is about 650 feet.

- Garden Gulch Member. The Garden Gulch Member consists primarily of gray and brown marlstone strata containing imbedded organic matter and minor amounts of siltstone, sandstone, and thin beds of oil shale. This member is not exposed on the tracts, but is found below depths ranging from about 800 to 1,250 feet. Its thickness varies from 220 to 250 feet beneath the tracts, as shown in Figures 2.2-4 and 2.2-5.

- Parachute Creek Member. The Parachute Creek Member includes the uppermost strata of the Green River Formation, and contains the most economically important sequences of oil shale strata within the Green River Formation. Its lithology is predominantly calcium carbonate mudstone, or marlstone, and dolomite, containing abundant organic matter interbedded with minor amounts of siltstone, sandstone, and altered volcanic tuff beds. Near the tracts, outcrops along the southeast perimeter of the Uinta Basin attain a maximum thickness of 900 feet, and like the other Tertiary formations in the Uinta Basin, thicken progressively in the subsurface from the vicinity of the tracts to the northwest. Strata within the upper 200 feet of the Parachute Creek Member are exposed within the eastern portion of the tracts, as shown in Figures 2.2-4 and 2.2-5. Most of the member, however, lies below the surface within the tracts as shown in the geologic cross section. Thickness of the member averages 730 feet beneath the tracts.

  The Mahogany Marker (Figure 2.2-6), a persistent and widespread key bed within the Parachute Creek Member, is an analcitized volcanic tuff bed that averages 6 inches in thickness, and lies 9 to 15 feet above the Mahogany bed that contains the richest oil shale beds in the basin. The Mahogany Marker weathers to orange-brown rectangular blocks, whereas the Mahogany bed outcrops as a light-gray-to-tan resistant ledge (Ref. 8) This marker bed dips at about 150 to 200 feet per mile to the northwest. The mahongany oil shale zone averages about 100 feet in thickness beneath the tracts, and, as reported by a preliminary Cleveland-Cliffs Geologic Exploration Program Report (Ref. 20), the proposed mining zone will extend from about 20 feet above to 40 feet below the mahogany marker.

A remarkably distinctive zone lies near the top of the Parachute Creek Member and is known informally as the "Bird's Nest Zone" because of its many ellipsoidal cavities formed by leaching out of nahcolite, a soluble sodium-bicarbonate mineral, from a matrix of predominantly siltstone and marlstone (Ref. 8). This zone is the principal aquifer above the Mahogany Zone in the vicinity of the tracts.

A prominent ledge-forming light-brown sandstone unit that lies immediately above the Bird's Nest Zone is believed to be, according to Cashion (Ref. 19), the "horse bench sandstone bed".

In the vicinity of the tracts, the horse bench sandstone bed varies from about 2 to 10 feet in thickness. Along Evacuation Creek within the tracts, this unit is composed of very fine sandstone and siltstone. Surface exposures of the horsebench sandstone are typically covered with white salt deposits, thereby suggesting groundwater seepage and evaporation from the outcrops.

2.2.3.2 Uinta Formation

The Uinta Formation, which overlies the Green River Formation, includes the most extensively exposed array of strata in the central Uinta Basin. Like the Green River Formation, the Uinta Formation is of Eocene age. Within Tracts U-a and U-b, the Uinta Formation crops out extensively (Figure 2.2-3) and in places attains a maximum thickness of about 1,000 feet. The formation has been divided by previous investigators into two units, Unit a and Unit b, based primarily upon the position of a tuffaceous sandstone bed approximately 2 to 6 feet thick that lies at the base of Unit b (designated "Tub" in Figure 2.2-3). Unit a, designated "Tua" in Figure 2.2-3, extends downward from the base of Unit b to the top of the Green River Formation. The lithology of both units is generally much the same: stream-deposited, fine-grained, light-reddish-brown sandstone and siltstone interbedded with minor amounts of shale and conglomerate.

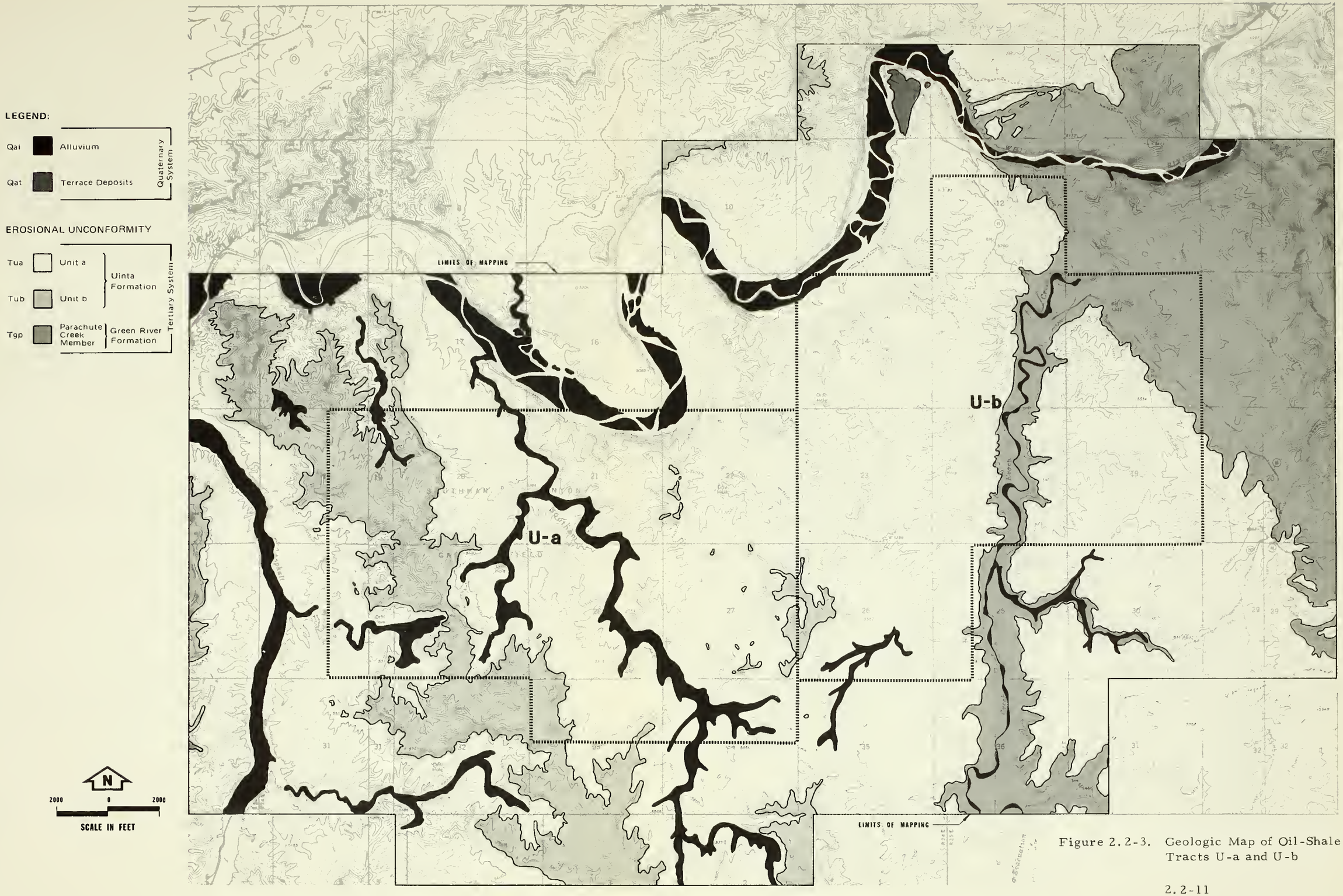
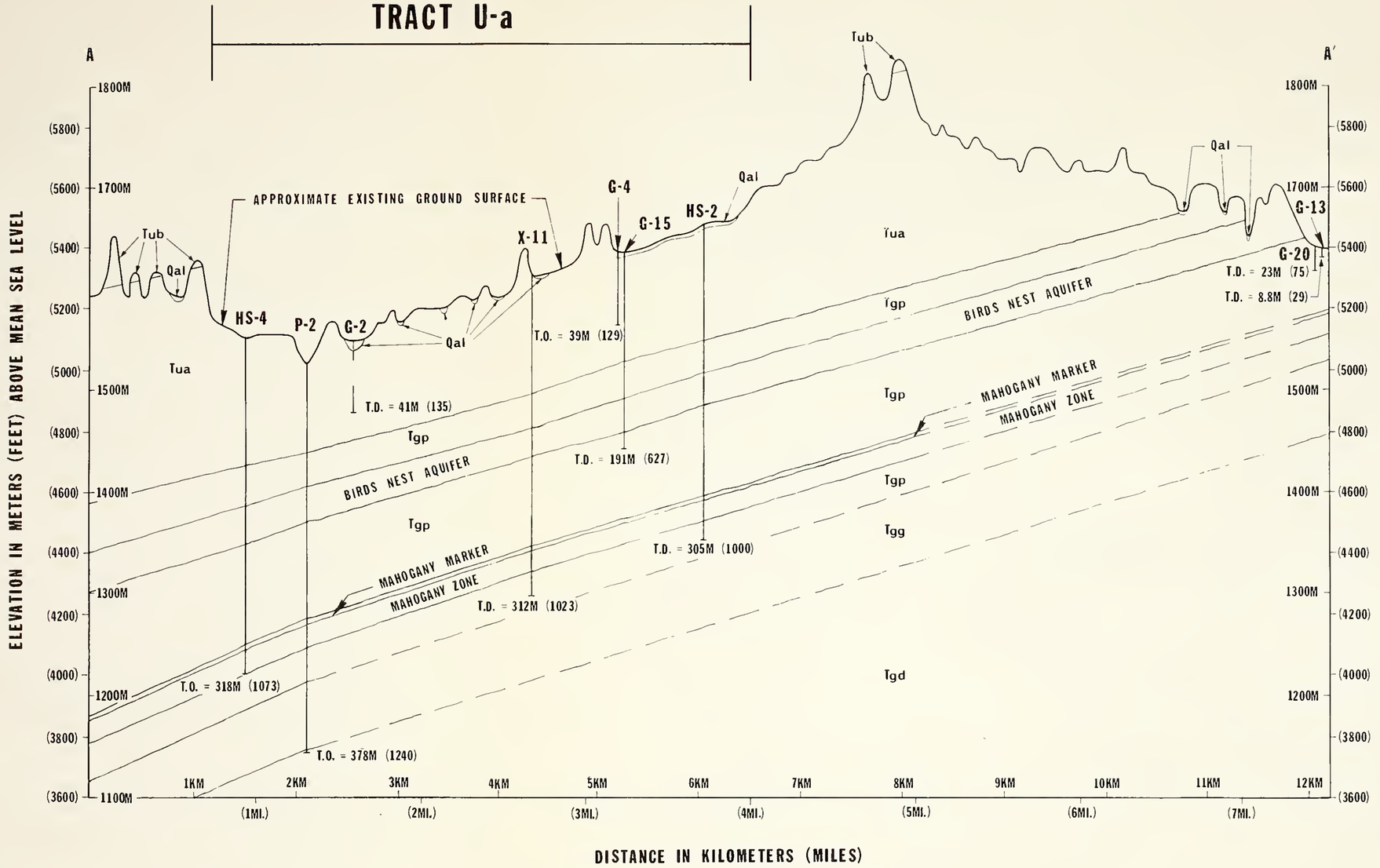


Figure 2.2-3. Geologic Map of Oil-Shale Tracts U-a and U-b



LEGEND

QUATERNARY

Qal ALLUVIUM

EROSIONAL UNCONFORMITY

TERTIARY

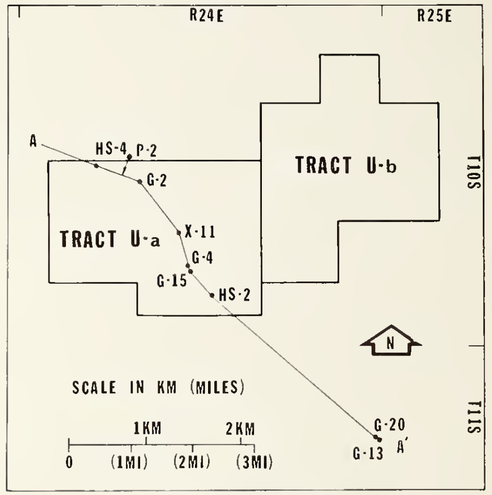
Tub UNIT b
Tua UNIT a
} UINTA FORMATION

Tgp PARACHUTE CREEK MEMBER
Tgg GAROEN GULCH MEMBER
Tgd DOUGLAS CREEK MEMBER
} GREEN RIVER FORMATION

T.D. TOTAL DEPTH OF BOREHOLE IN METERS (FEET)

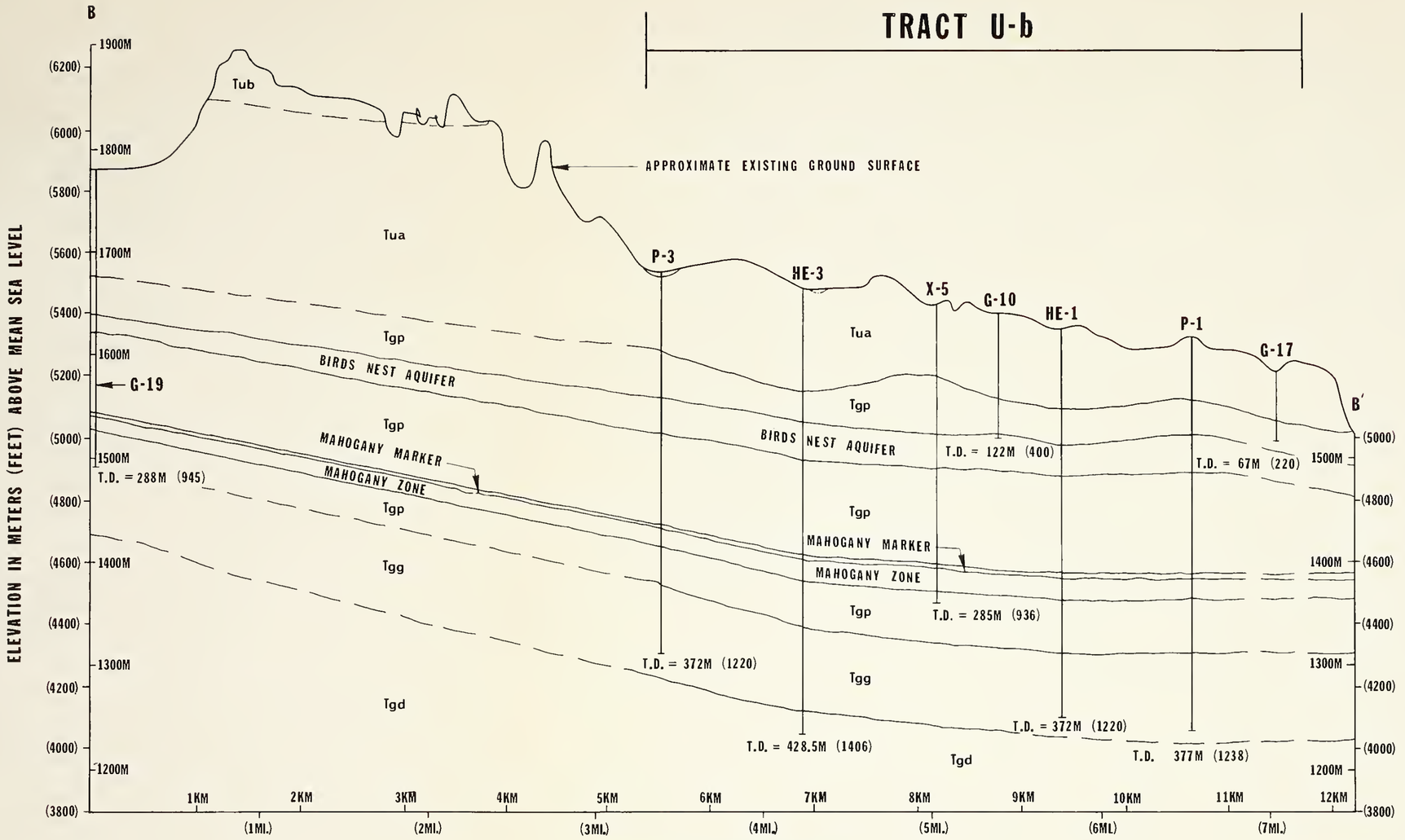
X-5 · BOREHOLES WITH PROJECT NO. DESIGNATION

NOTE: FORMATION CONTACTS DASHED WHERE INFERRED



LOCATION OF CROSS-SECTION

Figure 2.2-4. Geologic Cross-Section through Oil Shale Tract U-a



LEGEND

QUATERNARY

Qal ALLUVIUM

~~ EROSIONAL UNCONFORMITY

TERTIARY

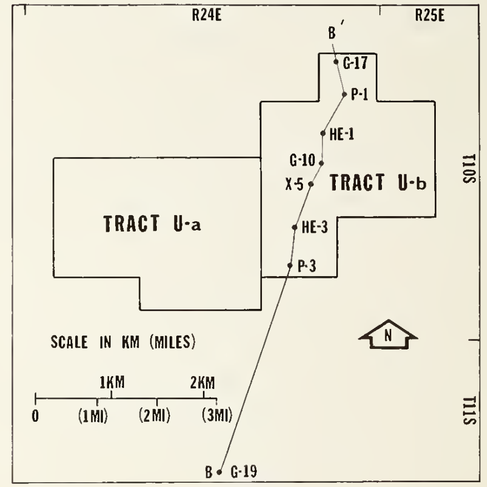
Tub UNIT b } UINTA FORMATION
Tua UNIT a }

Tgp PARACHUTE CREEK MEMBER }
Tgg GARDEN GULCH MEMBER } GREEN RIVER FORMATION
Tgd DOUGLAS CREEK MEMBER }

T.D. TOTAL DEPTH OF BOREHOLE IN METERS (FEET)

X-5• BOREHOLES WITH PROJECT NO. DESIGNATION

NOTE: FORMATION CONTACTS DASHED WHERE INFERRED.



LOCATION OF CROSS-SECTION

Figure 2.2-5. Geologic Cross-Section through Oil Shale Tract U-b

LEGEND

- •P PILOT TEST HOLE
- •G GROUND WATER MONITORING STATION
- •HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- •HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- •X EXPLORATION GEOLOGIC CORE HOLE

5400 / 1400 ○ SURFACE ELEVATION AND DEPTH TO MINING ZONE IN CIRCLED AREA SHOWN IN FEET (RANGES FROM APPROXIMATELY 400 FEET TO 1,400 FEET).

(4700) 1433M CONTOUR LINES SHOWING ELEVATION IN METERS (FEET) ABOVE SEA LEVEL OF THE MAHOGANY MARKER BED. A VOLCANIC TUFF BED WHICH LIES APPROXIMATELY 3-5 METERS (9-15) FEET ABOVE THE MAHOGANY OIL SHALE BED. CONTOURS DASHED WHERE INFERRED.

UTAH

N

SCALE

0 500 1000 1500 2000 METERS

0 1000 2000 4000 6000 8000 FEET

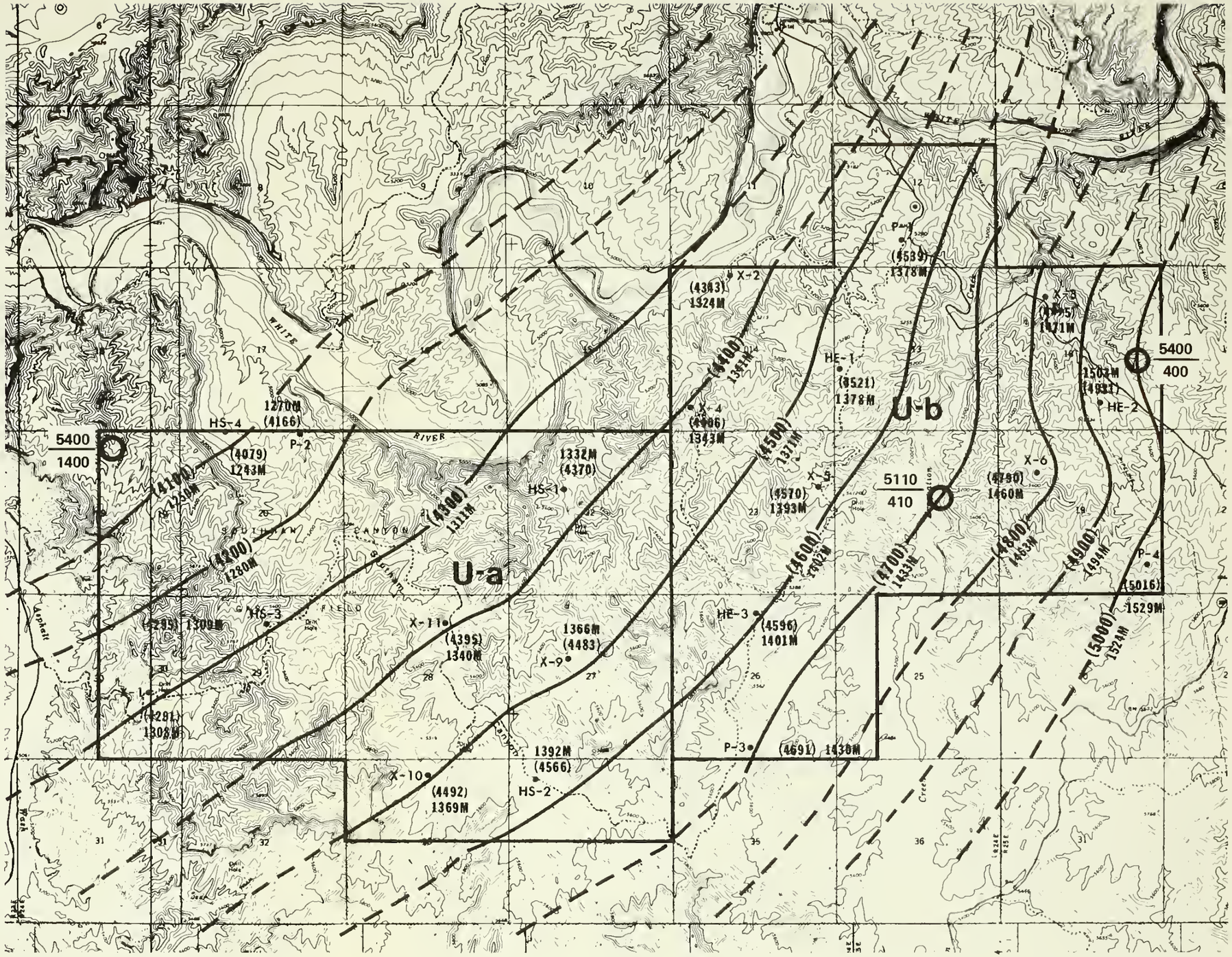


Figure 2.2-6. Subsurface Structural Contour Map of the Mahogany Marker Bed, Tracts U-a and U-b

2.2.3.3 Quaternary Alluvium

Within Tracts U-a and U-b, quaternary alluvium occurs along Evacuation Creek Canyon, within Southam Canyon, along the White River, and also in some isolated patches along drainages where they pass over outcrops of the Uinta Formation. The geologic map of Tracts U-a and U-b shows areas covered by alluvium (Figure 2.2-3).

The Southam Canyon alluvium is composed primarily of light-reddish-brown silt and fine sand and attains an estimated maximum thickness of about 40 feet. In the southern portion of Southam Canyon at Well Site AG-7, the alluvium is 37 feet. Alluvium in Evacuation Creek Canyon occurs in patches that reach their maximum thickness along the inside and downstream portions of meander loops of the creek. Estimated maximum thickness of all alluvium along Evacuation Creek Canyon is 21 feet. Since this canyon is being formed by erosion down through the Uinta Formation and into the Green River Formation, the alluvium is composed predominately of a mixture of coarse-grained, platy marlstone fragments, fine-to-medium sand, and sand-sized limestone fragments. Isolated patches of alluvial material that have been deposited on outcrops of the Uinta Formation are basically light-reddish-brown fine silty sand. Along the White River the alluvium is primarily light-brown fine sand with some gravel. The maximum thickness of the alluvium along the White River near the tracts is about 35 to 50 feet.

2.2.4 STRUCTURAL GEOLOGY

Geologic structure within the vicinity of the site is quite uniform. The strata generally dip less than 5 degrees (below horizontal) toward the north or northwest, and no surface expression of faulting is exhibited. The Mahogany Marker bed reveals the orientation of strata within the proposed mining zone and generally dips about 150 to 200 feet per mile toward the northwest (Figure 2.2-6).

Extraordinary sets of near-vertical joints (rock fractures) occur throughout the site area. Since the joints are very important in the overall strength and stability of the strata, they have been mapped and analyzed in detail. Considering all joints mapped within the entire site area, the primary set trends north 62 degrees west and dips 86 degrees toward the southwest. Three secondary sets are also present, possessing trends that are north 22 degrees east, north 18 degrees east, and north 33 degrees east, with dips that are respectively 88 degrees northwest, 88 degrees southeast, and 87 degrees southeast. The character of the joints that are formed in the Uinta Formation is, as a rule, quite changeable. Smooth, large, flat open joints are the most noticeable in the field; however, there are also numerous small, rough, closed joints throughout the section.

2.2.5 GEOLOGIC HAZARDS

2.2.5.1 Seismicity

Seismic risk is defined as the probability of earthquake damage from ground shaking, subsidence, differential settlement, ground cracking, or liquefaction. Three zones of seismic risk, based on historic earthquake occurrence, have been identified for the western U.S. (Ref. 21). Tracts U-a and U-b lie within the lowest risk zone. No active surface faults have been reported in the vicinity of the tracts.

2.2.5.2 Landslides and Rockfalls

Ancient landslides are evident along many of the steep cutbanks of the White River. Examples are evident on the tracts of recent debris flows within steep drainages and rockfalls along sharp ridges. Areas that are particularly susceptible to rockfalls are shaded darkest gray or black on the site slope gradient map (Figure 2.2-2). Severe thunderstorms and accompanying flash floods are the primary forces causing landslides and debris flows.

2.2.6 MINERAL RESOURCES

Economically important deposits of minerals within the Uinta Basin are shown in Figure 2.2-7.

2.2.6.1 Oil and Natural Gas

Altogether there have been eight holes drilled for oil and gas exploration on Tracts U-a and U-b. Only one of these holes, located in the central portion of Tract U-a within Southam Canyon, has produced economically valuable quantities of oil and gas. The other on-tract exploratory holes were dry. Nearby, however, a group of about 14 productive gas wells have been completed and are located approximately 4 to 5 miles southwest of Tract U-a. Another three productive gas wells are located 1.5 to 3 miles northwest of Tract U-a. Although these wells penetrate the entire thickness of the Eocene strata, the principal productive zone, the Mesa Verde Formation of Cretaceous age, lies considerably deeper in the section. For estimates of the original hydrocarbon quantities and the total production from each field up through 1968, see Ref. 22.

2.2.6.2 Oil Shale

Oil shale is not shale at all, but is actually a dense, tough, thinly bedded, dark-to-olive-brown to brownish-black marlstone. The organic fraction of oil shale was derived from microorganisms that originally flourished in shallow tropical lakes and from pollen, spores, and fragments of land plants blown into the ancient lake system. The inorganic fraction of the oil shale is composed mainly of dolomite and calcite, with minor amounts of quartz, feldspars, analcime, clay, and pyrite (Ref. 23). Cashion (Ref. 8) defined oil shale as marlstone that will yield at least 15 gallons per ton.

2.2.6.3 Gilsonite

Classed as an asphaltite, Gilsonite is a black tar-like brittle substance which has been formed as a residue of natrual petroleum. Homogeneous veins of Gilsonite occur along straight and continuous northwest-trending joints and minor faults in the east-central Uinta Basin, but primarily within the Uinta Formation.

Other economic and potentially economic mineral resources found in the Uinta Basin (Figure 2.2-7) include bituminous sandstone, coal, uranium, gypsum, and nahcolite.

2.2.7 SOILS

2.2.7.1 Regional Soils

The soil associations that occur in Tracts U-a and U-b are #51 and #63, as classified by the Soil Conservation Service. Soils of Association #51 occur along the White River. At this site they are Aquic Ustifluvents and constitute about 25 percent of Association #51. The remainder of the soils in the tracts are typic Torriorthents, Lithic Calcionthids, and Lithic Natragids. For the major portion of the tracts, Torriorthent soils are more stony than indicated on regional soils maps while the Natragids soils are less stony than indicated.

2.2.7.2 Soil Types

Twenty-four soil mapping units are shown on the soil map of Tracts U-a and U-b (Figure 2.2-8). Most of the map units are composed of A(5 types), As (5 types), B(3 types), and Bs(6 types) soils. Small areas of D, W, E, F, and N soils and complexes of these are also found.

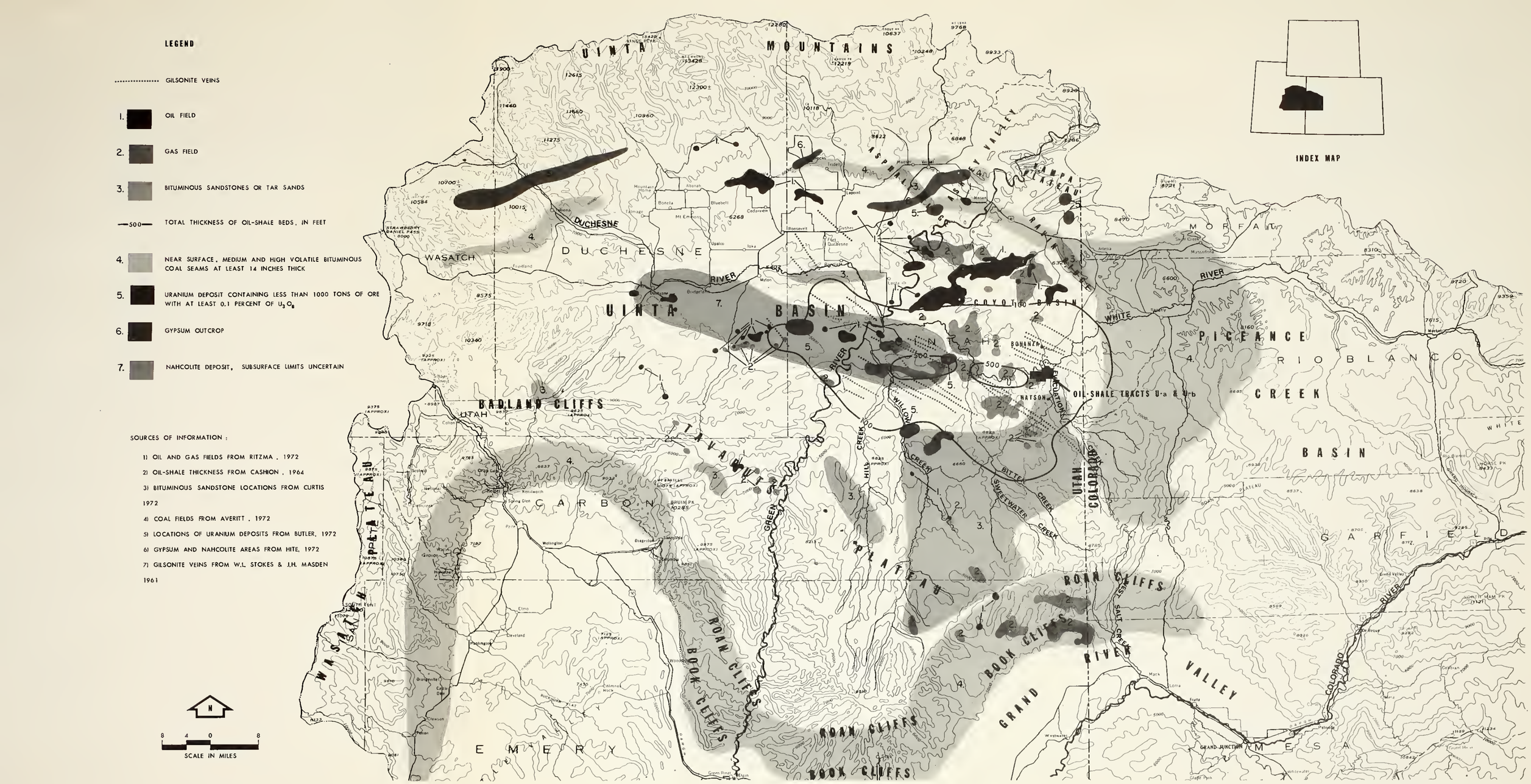


Figure 2.2-7. Mineral Resources of the Uinta Basin

LEGEND

A(1-5) - SHALLOW CHANNERY LOAMS, 3 TO 40 PERCENT SLOPES

As(1-5) - SHALLOW CHANNERY SANDY LOAMS, 5 TO 60 PERCENT SLOPES

B(1-3) - SHALLOW CHANNERY AND FLAGGY LOAMS, 5 TO 40 PERCENT SLOPES

Bs(1-6)(R) - SHALLOW CHANNERY AND FLAGGY SANDY LOAMS, 10 TO 60 PERCENT SLOPES

Ds(D) - SANDY LOAMS, 5 TO 10 PERCENT SLOPES

E (EN) - DEEP LOAMS, 5 TO 10 PERCENT SLOPES

F (FR) - SHALLOW LOAMY SANDS, 3 TO 7 PERCENT SLOPES

N (NE, BD) - DEEP, MODERATELY FINE TEXTURED SOIL, 5 TO 10 PERCENT SLOPES

W - DEEP SILTY ALLUVIUM, 0 TO 2 PERCENT SLOPES

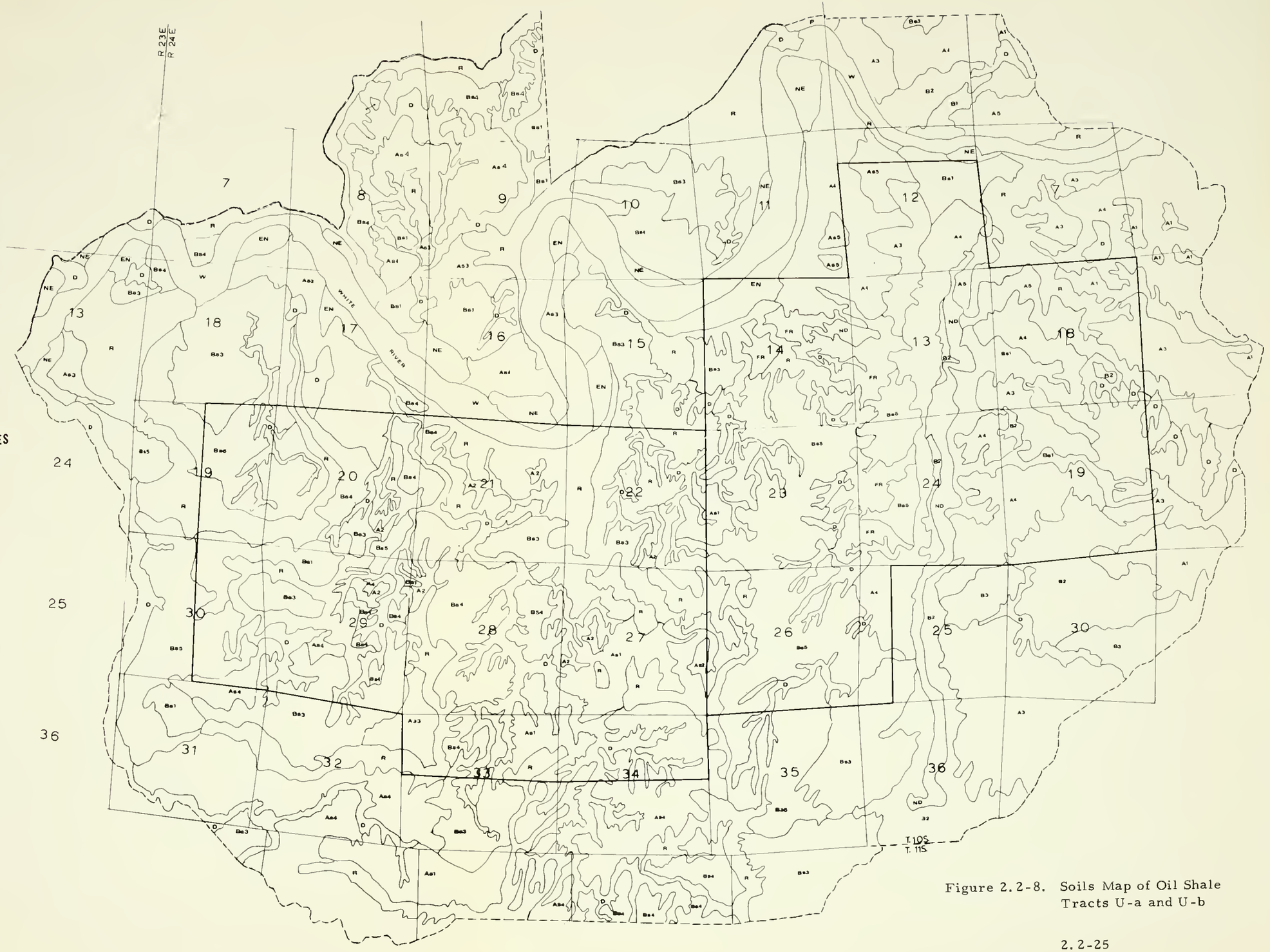


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PHOTO MOSAIC; NOT TO SCALE

Figure 2.2-8. Soils Map of Oil Shale Tracts U-a and U-b

The soils of Tracts U-a and U-b consist of shallow to very shallow (less than 20 inches deep) soils on sloping to steep upland surfaces cut by numerous intermittent drainages and containing many areas of rock outcrops and rock escarpments.

Soils A, As, B, Bs, and F are included in these shallow sites. They consist of sandy loam, loams, channery sandy loams, and channery loams. The content of coarse fragments (channers and flaggs) usually increases with depth, and numerous flagstones, with a small proportion of soil, may be found immediately above the bedrock. Surface soils are light-colored and moderately calcareous. The $CaCO_3$ (lime) content as a rule increases with depth and occurs as a coating on the undersides of rock fragments.

Numerous drainage courses are found throughout the tracts. Most of these have intermittent stream channels, and the soils along these channels are generally deep (more than 60 inches). The D soils occur in these areas and are most extensive in the Southam Canyon drainage area. They are mainly sandy loams or channery sandy loams, light-colored and moderately calcareous.

Along the Evacuation Creek drainage, the D soils are associated with N soils. The latter are deep, moderately fine textured, and strongly alkaline, with a high concentration of exchangeable sodium. The N soils also are found on stream terraces about 50 to 1000 feet above the White River flood plain. In these areas the N soils occur with E soils. The E soils are deep, moderately coarse textured, with a strong $CaCO_3$ (lime) horizon in the subsoil.

W soils occur adjacent to the White River, mainly in the corridor outside Tracts U-a and U-b. These are deep, silty soils that are seasonally wet in deeper horizons and generally have a high salt content.

2.2.7.3 Soil Infiltration

A soil infiltration study was conducted to provide baseline data for the evaluation of major effects to the soil as a result of land use changes, and to provide information for Soil Conservation Service (1972) modeling of surface water runoff.

Because of the limited ability of a small portable infiltration test device to replicate actual conditions, the data furnished are best if used as a comparison between soil types.

Upland soils have infiltration rates of 1.4 inches per hour, and bottomlands soils (D soils) have rates of about 2.4 inches per hour. The soils formed on the alluvium of the White River (W soil) have much slower rates of uptake, about 0.6 inch per hour, because of their high silt and clay content. As would be expected, soils affected by excess sodium (N soil) have the lowest infiltration rates, about 0.3 inch per hour.

Infiltration rates did not decrease dramatically during the 28-minute period of the test. Most runs showed no time trend. A few runs had a small initial decrease with time. In addition, soil type was apparently more significant in determining infiltration rates than slope angle. Infiltration rates from test plots on dry soils were generally about 1 inch per hour greater than the rates on wet soils.

2.2.7.4 Soils Engineering Properties and Interpretations

Many properties of soil, such as permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction, are important to engineering uses. Also important are slope, depth to bedrock, and depth to the water table. Engineering data and interpretations for the soils are presented in Tables 2.2-1 and 2.2.2.

The Unified and AASHO Engineering Classification Systems show that most of the soils within the tracts have relatively high bearing strengths. E, N, and W soils, however, are not desirable as base material in construction. All soils except E, N, and W are nonplastic.

Permeability for most of these soils is moderate to moderately rapid, but for the N soils, permeability is slow. Available water capacity for these soils is rather low. The pH values indicate that the soils are mildly to strongly alkaline. Electrical conductivities (EC in mmhos/cm) indicate a wide range in the salinity of most of these soils (0.3 to 28.0 mmhos/cm). Shrink-swell potentials are low, with the exception of the N and W soils, which have moderate shrink-swell potentials. Runoff potentials of the soils vary from moderately low to high.

Owing to their shallowness and excessive slopes, the A, As, B, and Bs soils are unsuited for septic tank absorption fields, sewage lagoons, sanitary landfills, shallow excavations, dwellings, or local roads. F soils are also unsuited because of shallowness, while W soils are unsuited because of seasonal high water table and flood hazard. N soils have some limitations for these uses, because of moderately slow permeability and moderate shrink-swell potential. The Ds and E soils have few limitations and are suitable for these uses.

The A, As, B, Bs, and Ds soils are good to fair as a source of roadfill. The E, F, N, and W soils are fair to poor for roadfill use. All of these soils are poor or unsuitable as sources of sand and gravel.

Soils D and W are the best source of topsoil. The Southam Canyon area, where the processed shale will be deposited, contains about 640 acres of D soils. The W soils are most commonly found along the White River Valley.

2.2.7.5 Soil Radioactivity

Measurements of soil radioactivity were made in order to establish base-line levels of radioactivity in the area, and to separate the contributions from (1) radioactivities originating from nuclides within the oil shale (usually from nuclides in a uranium decay chain, which could affect the environment), (2) naturally occurring background activity, and (3) radio-activity identified with the worldwide fallout from weapons testing. The radiation levels in the soils of the tracts are primarily associated with sources of nuclear radiation from the naturally occurring background activity. The results are viewed from this perspective.

A number of soil samples were collected from representative locations on the two lease tracts and analyzed for radioactivity. No sources above a normal background level were identified, with Ra^{226} activity below 0.87 pCi/g, Sr^{90} below 0.52 pCi/g, K^{40} below 20 pCi/g, Pb^{212} below 1.5 pCi/g, Cs^{137} below 1.6 pCi/g for all samples.

Table 2.2-1

ESTIMATED AND MEASURED SOIL PROPERTIES SIGNIFICANT TO ENGINEERING NEEDS

Soil	Slope Range (%)	Depth to Bedrock (cm)	Texture Class	Unified	AASHO	Liquid Limit	Plastic Limit	Permeability (in./hr)	Water Capacity Available (in./in.)	pH	EC mmhos/cm	Shrink-Swell Potential	Hydrologic Soil Groups
A	3 to 40	30 to 50	Channery loam	SM GC	A-2-4	24-33	NP-0	1.0-2.5	0.9-0.11	7.5-8.7	0.4-5.4	Low	C (moderately high level of potential)
As	5 to 60	30 to 50	Channery sandy loams	SM GM	A-2-4	24-36	NP	1.5-3.0	<0.1	8.1-8.5	0.3-6.0	Low	C (moderately high level of potential)
*B	5 to 40	5 to 25	Channery loams	SM GM	A-2-4	20-30	NP	1.0-2.5	<0.1	7.5-8.2	0.7-3.0	Low	D (high runoff potential)
*Bs	10 to 60	5 to 25	Channery sandy loams	SM GM	A-2-4	20-30	NP	1.5-3.0	<0.1	7.5-8.3	0.7-2.5	Low	D (high runoff potential)
Ds	5 to 10	150+	Sandy loam to channery sandy loam	SM	A-2-4	20-23	NP	1.0-2.5	0.12-0.14	7.9-8.3	1.0-19.0	Low	B (moderately low runoff potential)
E	5 to 10	150+	Fine sandy loams to loams	M L C L S M	A-4 A-6	20-27	NP-8	1.0-2.5	0.14-0.16	7.7-8.6	0.4-18.0	Low	B (moderately low runoff potential
*F	3 to 7	10 to 40	Loamy sands	SM	A-2	20-30	NP	2.0-4.0	<0.1	8.1-8.5	0.3-0.6	Low	D (high runoff potential)
*N	5 to 10	150+	Fine sandy loam surface silty clay loam subsoil	CL	A-4 or A-6	20-30	5-15	0.05-0.20	0.14-0.16	8.1-8.9	5.0-15.0	Moderate	D (high runoff potential)
W	0 to 2	150+	Silt loams to silty clay loams — some sands	CL SM	A-4 A-6	20-47	2-16	0.80-2.0	0.16-0.18	8.0-8.3	1.5-28.0	Moderate	B (moderately low runoff potential

*Estimate

Table 2.2-2

INTERPRETATIONS OF ENGINEERING PROPERTIES OF SOILS

Degree and Kind of Limitation for									Suitability as a Source of					
Soil	Septic Tank Absorption Fields	Sewage Lagoons	Sanitary Landfill Trench type	Sanitary Landfill Area type	Shallow Excavations	Dwellings w/without Basements		Local Roads & Streets	Roadfill	Sand	Gravel	Topsoil	Sanitary Landfill Cover Materials	Cover Processed Shale Deposit
A	Severe-slope depths	Severe-slope depths	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited loam	Poor loam shallow	Poor channery and flaggy	Poor shallow	Poor shallow
As	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited sandy loam	Poor sandy loam shallow	Poor, very channery and flaggy	Poor shallow	Poor shallow
B	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited loam	Poor loam shallow	Poor, very channery and flaggy	Poor very shallow	Poor very shallow
Bs	Severe-slope depth	Severe-slope depth	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Severe-depth slope	Good to fair A-2-4	Unsuited sandy loam	Poor sandy loam shallow	Poor, very channery and flaggy	Poor very shallow	Poor very shallow
Ds	Slight-5 to 10% slopes	Moderate-5 to 10% slope	Slight	Slight	Slight	Slight	Slight	Slight	Good to fair A-2-4	Unsuited sandy loam	Unsuited	Fair, Channer Content increases with depth	Fair to good	Fair to good
E	Slight-5 to 10% slope	Moderate-5 to 10% slope	Slight	Slight	Slight	Slight	Slight	Slight to moderate A-6 material in subsoil	Fair A-4 A-6	Unsuited sandy loam and loam	Unsuited	Fair to 20 cm	Fair to good	Fair to good
F	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Severe-depth	Fair A-4	Poor shallow loamy sand	Unsuited	Poor, shallow loamy sand	Poor, shallow loamy sand	Poor shallow
N	Severe-moderately slow permeability	Severe-moderately slow permeability	Moderate-moderately slow permeability	Moderate-moderately slow permeability	Slight	Moderate-moderate shrink-swell	Moderate-moderate shrink-swell	Moderate moderate shrink-swell	Fair to poor A-4 A-6	Unsuited silty clay loam	Unsuited	Poor, alkaline salts	Poor alkaline salts	Poor, alkaline salts
W	Severe-seasonal high water table. Flood danger	Severe-seasonal high water table. Flood danger	Severe-seasonal high water table. Flood danger	Severe-seasonal high water table. Flood danger	Moderate-seasonal high water table. Flood danger	Severe-flood danger. Season high water table.	Severe-flood danger. Season high water table.	Severe-flood danger. Season high water table.	Fair to poor A-4 A-6	Poor silt loam Inclusive of fine sand	Unsuited	Good silt loam poor fine sand	Good	Fair high salt content in subsoil

Section 2.3

Section 2.3

WATER RESOURCES

2.3.1 SURFACE WATER

2.3.1.1 Surface Water Hydrology

Streams within the vicinity of the Oil Shale Tracts U-a and U-b are drainage elements of the White River Basin, a major subbasin of the Green River System. The White River flows generally westward, and the steams that drain from the oil shale tracts flow generally northward. The White River gathers most of its flow from the mountain area in Western Colorado, called the Flat Tops, with only minor flows added in the remaining four-fifths of the drainage area that lies between the mountains and the confluence with the Green River. Below Meeker, Colorado, however, the water quality deteriorates because of sediment and dissolved solids contributed by washes and groundwater seeps. This lower portion of the basin, within which the oil shale tracts lie, is an arid region having very few perennial streams. Of the major tributary drainages within the vicinity of the oil shale tracts (Hells Hole Canyon, Evacuation Creek, Southam Canyon, and Asphalt Wash), only Evacuation Creek sustains flow (in the lower reaches) during most of the year; the others flow only during periods of snowmelt or rainfall.

White River. The White River at the study area has a drainage area of about 4,000 square miles. The mean annual flow of the White River at Station S-3 for the period between 1923 and 1974 was 702 cubic feet per second (cfs). Mean daily flow, temperature, and specific conductance during the study period are shown in Figure 2.3-1. For 1975, the flow of the White River approached the mean flow, although the spring snowmelt occurred somewhat later than usual. The White River gains little

flow in the tract area, with most of what is contributed coming from groundwater. Peak flows normally occur in the spring, as mountain snow melts, and low flows occur during fall or winter months when mountain sources contribute very little water. On the basis of records collected on the White River near Watson, Utah, the 100-year, 1-day peak flow is about 6,300 cfs, and the 10 year, 7-day low flow is about 140 cfs.

Evacuation Creek. Evacuation Creek has a drainage area of 280 square miles. It flows throughout most of the year along some reaches, although periods of no flow occurred during July and August. Since precipitation approached the historic average of 10 inches on the tract area during the first year of the baseline monitoring, streamflow in Evacuation Creek (Figure 2.3-2) was probably average (there are no previous records for comparison). The estimated 25-year instantaneous peak flow in Evacuation Creek, as computed using regression techniques, is 1,330 cfs, while the peak flow measured during the first year of monitoring was 287 cfs.

Southam Canyon. Southam Canyon has the smallest area, 9 square miles, of any of the drainages. As can be expected for a small basin in an arid region, flow is very infrequent. During the first year of the baseline monitoring program, flow occurred on only 3 days as gauged at the mouth of the canyon, with the highest mean daily flow being 4.7 cfs. The estimated 25-year instantaneous peak flow is 80 cfs, while the peak flow measured during the first year of monitoring was 22 cfs.

Asphalt Wash. Asphalt Wash has a drainage area of 100 square miles. Despite this large area, there was a measurable flow on only 4 days during the first year. The highest mean daily flow was 2.5 cfs. The estimate 25-year peak flow, as computed using regression techniques, is 540 cfs.

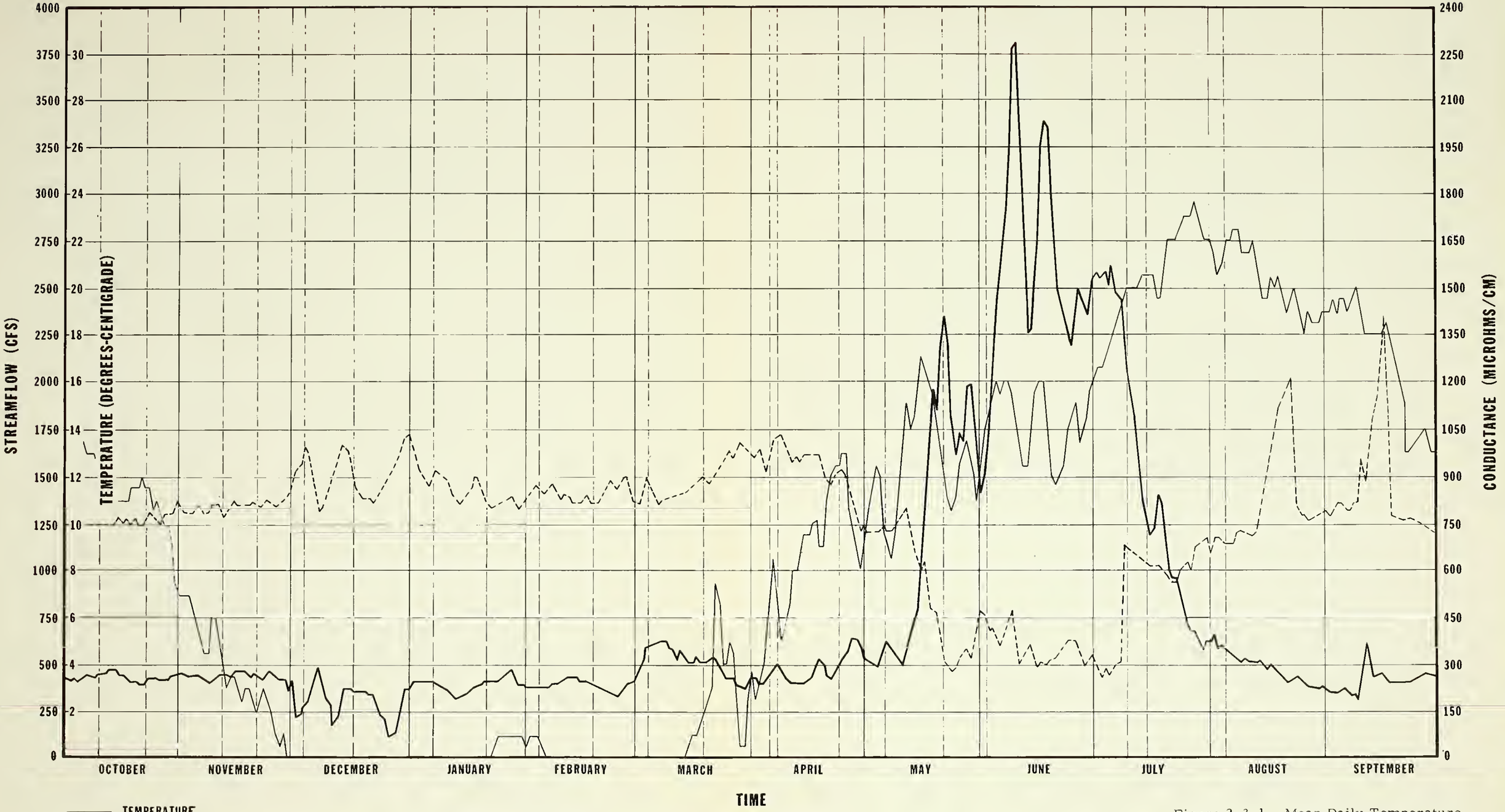

Figure 2.3-1. Mean Daily Temperature, Streamflow, and Specific Conductance of the White River near Watson, 1975

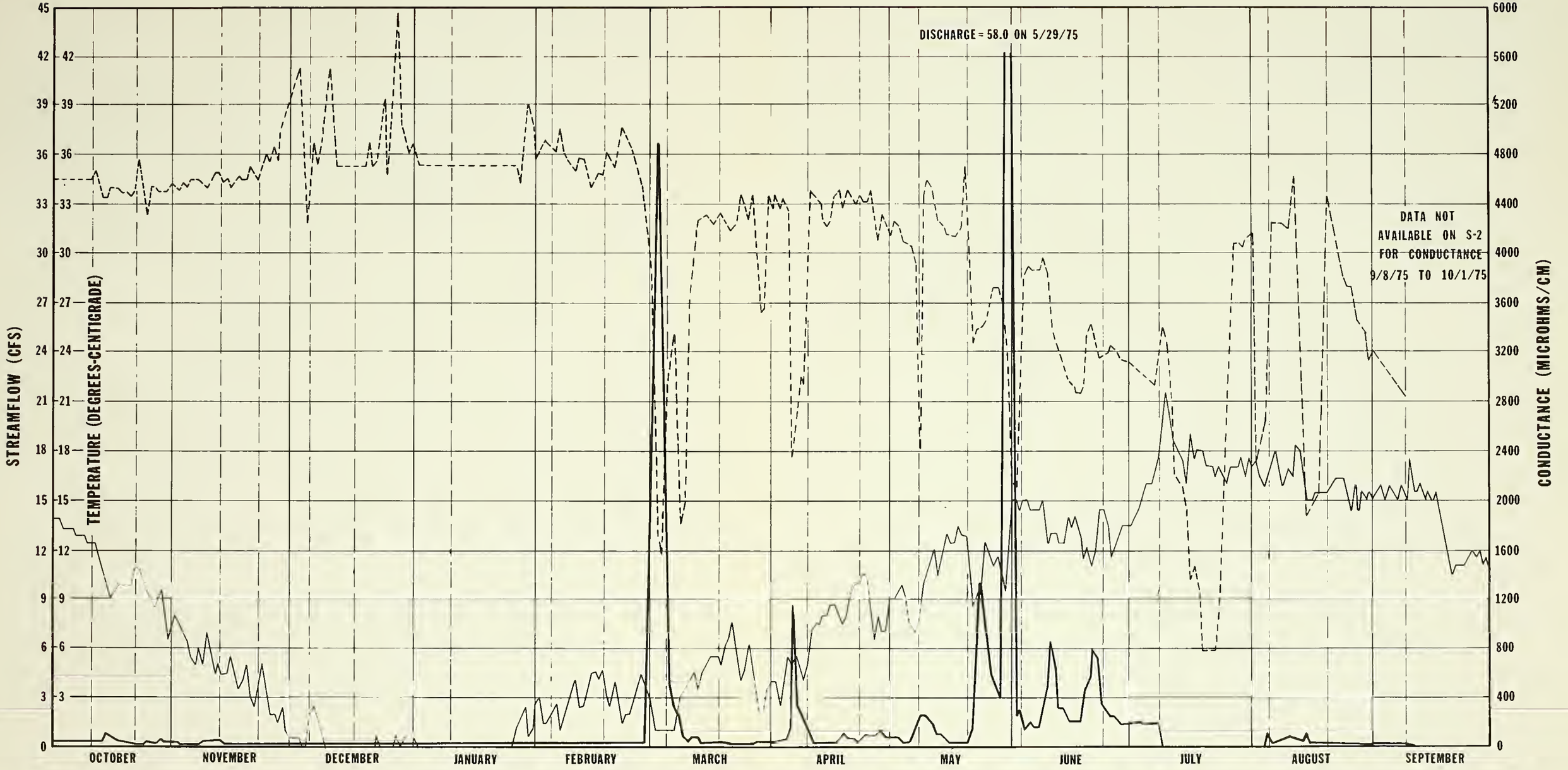

Figure 2.3-2. Mean Daily Temperature, Streamflow, and Specific Conductance of Evacuation Creek at Watson, 1975

Hells Hole Canyon. Hells Hole Canyon has about 26 square miles, making it the fourth largest drainage area considered here. Flows were measured at the mouth of Hells Hole Canyon for 15 days during the first year of monitoring. The highest mean daily stream flow was 31 cfs, although a peak flow in excess of 280 cfs followed an intense thunderstorm (based upon indirect USGS procedures). This exceeds the estimated 25-year peak flow of 210 cfs (computed using regression techniques).

2.3.1.2 Surface Water Quality

White River. From May through July, most of the flow of the White River comes directly from snowmelt and is therefore low in dissolved solids, although high in sediment load. From September through February, the pattern is reversed; the concentration of dissolved solids increases while that of suspended sediment decreases. This is the result of the change in flow from predominantly surface snowmelt to predominantly groundwater, containing high levels of dissolved solids leached from soil and rock. Specific conductance, which is measured more frequently than dissolved solids and is shown on Figure 2.3-1, can be used to estimate dissolved solids concentrations. Considering both the specific conductance record and the dissolved solids measurements, the White River carried between 300,000 and 450,000 tons of dissolved material during the year. During the baseflow period, chemical quality showed little variation, but during high flow, concentrations showed much wider ranges. As can be expected, this pattern follows flow variations.

Tables 2.3-1 and 2.3-2 summarize the first-year chemical quality data at Station S-3 near the White River bridge, which is representative of all four White River stations. In general, White River water can be regarded as very hard and somewhat alkaline. No trace elements were found in unusually high levels. Coliforms were found in low to moderate concentrations, with pesticides and herbicides below detection limits.

Table 2.3-1

SUMMARY OF WATER QUALITY
WHITE RIVER NEAR WATSON (S-3)
Base Flow Period: August 1974 through May 1975

	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (°C)	19	8.0	9.1	28.5	0
Turbidity (JTU)	12	128	205	680	5
Conductance (μmhos)	20	834	94	1,010	630
Chemical Oxygen Demand (mg/l)	17	10	10	38	0
pH (pH Units)	14	8.2	0.2	8.6	7.9
Carbon Dioxide (mg/l)	4	2.4	1.0	4.6	1.5
Alkalinity (mg/l $CACO_3$)	20	199	17	236	172
Bicarbonate (mg/l HCO_3)	20	241	21	288	208
Carbonate (mg/l CO_3)	18	0.2	0.7	3	0
Filterable Residue (mg/l)	8	580	68	690	500
Oil and Grease (mg/l)	16	3	2	6	0
Ammonia (mg/l N)*	18	0.06	0.05	.19	.01
Nitrite (mg/l N)*	17	0.00	0.00	.01	.00
Nitrate (mg/l N)*	16	0.13	0.14	.39	.00
Kjeldahl Nitrogen (mg/l N)	20	0.36	0.23	.94	.10
NO_2 + NO_3 (mg/l N)*	20	0.13	0.13	.37	.00
Orthophosphate (mg/l PO_4)*	20	0.06	0.04	.15	.00
Phosphorus (mg/l)	17	0.12	0.17	.74	.00
Orthophosphorus (mg/l P)*	20	0.02	0.01	.04	.00
Total Organic Carbon (mg/l)	3	7.2	5.0	13	4.1
Total Inorganic Carbon (mg/l)	1	32	–	–	–
Cyanide (mg/l)	9	0.00	0.00	.01	.00
Sulfide (mg/l)*	17	0.1	0.1	.3	.0
Hardness (mg/l Ca, Mg)	20	299	44	460	270
Noncarbonate Hardness (mg/l)	20	100	40	260	72
Calcium (mg/l)*	20	72	12	120	60
Magnesium (mg/l)*	20	29	4	39	24
Sodium (mg/l)*	20	78	16	120	60
Sodium Adsorption Ratio	20	2.0	0.3	2.7	1.0
% Sodium	20	36	2.3	40	28
Potassium (mg/l)*	20	2.3	0.5	2.8	1.0
Chloride (mg/l)*	20	42	10	79	13
Bromide (mg/l	13	0.1	0.0	0.2	0.0
Sulfate (mg/l)*	20	188	26	250	81
Fluoride (mg/l)*	20	0.3	0.1	.4	.2
Silica (mg/l)*	20	13	2	17	10
Arsenic (mg/l)*	10	0.002	0.001	0.004	0
Barium (mg/l)*	10	<0.100	–	<.1	–
Beryllium (mg/l)*	4	<0.01	–	<.01	–
Bismuth (mg/l)*	2	<0.01	–	<.011	–
Boron (mg/l)*	12	.088	0.026	.130	–
Cadmium (mg/l)*	10	<0.001	–	<.001	–
Chromium (mg/l)*	11	<0.01	–	<.01	–
Cobalt (mg/l)*	11	<0.001	–	<.001	–
Copper (mg/l)*	10	0.003	0.002	.006	.001
Iron (mg/l)*	9	0.023	0.011	.270	.010
Lead (mg/l)*	10	0.001	0.001	.002	.000
Manganese (mg/l)*	10	0.009	0.011	.030	.000
Mercury (mg/l)	10	0.00003	0.00007	.0002	.0000
Molybdenum (mg/l)*	10	0.003	0.001	.004	.001
Nickel (mg/l)*	10	0.003	0.004	.012	.000
Silver (mg/l)*	4	<0.001	–	<.001	–
Strontium (mg/l)*	4	1.010	0.064	1.100	.950
Vanadium (mg/l)*	10	0.0015	0.0013	.0042	.00
Zinc (mg/l)*	10	<0.025	0.031	.110	.010
Tin (mg/l)*	2	0.01	–	<.011	–
Aluminum (mg/l)*	10	0.018	0.015	.050	.00
Gallium (mg/l)*	2	<0.005	–	<.005	–
Germanium (mg/l)*	2	<0.011	–	<.011	–
Lithium (mg/l)*	10	<0.015	–	.03	–
Selenium (mg/l)*	9	<0.001	0.001	.002	.001
Titanium (mg/l)*	2	<0.008	–	<.008	–
Zirconium (mg/l)*	2	<0.018	–	<.018	–
Gross Beta (mg/l Cs_{137})*	6	0.0055	0.0031	.012	.00
Chlorophyll A (mg/l)	6	0.0024	0.0021	.0058	.0003
Chlorophyll B (mg/l)	6	0.0011	0.0007	.0025	.0005
Phenols (mg/l)	14	0.0029	0.0024	.006	.00
Dissolved Solids (mg/l)*	17	551	54	676	278
Gross Alpha (mg/l U)*	8	<0.014	–	.035	–
Gross Beta (mg/l SR_{90}/Y_{90})*	8	0.0049	0.003	9.9	2.4
Dissolved Oxygen	See text for information.				

*Elements analyzed only for dissolved fraction.

Table 2.3-2

SUMMARY OF WATER QUALITY
WHITE RIVER NEAR WATSON, UTAH (S-3)
High Flow Period: May through August 1975

	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (°C)	7	16.3	4.6	22.0	10.5
Turbidity (JTU)	6	389	283	800	76
Conductance (μmhos)	7	533	165	760	330
Chemical Oxygen Demand (mg/l)	6	40	23	81	19
pH (pH Units)	7	8.4	0.8	10.1	7.4
Carbon Dioxide (mg/l)	7	2.8	3.4	10	0.0
Alkalinity (mg/l $CACO_3$)	7	145	31	196	107
Bicarbonate (mg/l HCO_3)	7	154	77	239	131
Carbonate (mg/l CO_3)	7	0	-	0	0
Filterable Residue (mg/l)	3	360	115	490	270
Oil and Grease (mg/l)	6	1.3	0.5	2	1
Ammonia (mg/l N)*	6	0.03	0.05	0.13	0.00
Nitrite (mg/l N)*	6	0.002	0.004	0.01	0.00
Nitrate (mg/l N)*	6	0.11	0.12	0.33	0.01
Kjeldahl Nitrogen (mg/l N)	6	1.9	1.1	3.3	0.86
$NO_2 + NO_3$ (mg/l N)*	7	0.10	0.11	0.33	0.01
Orthophosphate (mg/l PO_4)*	7	30	79	210	0.00
Phosphorus (mg/l)	6	0.38	0.41	1.1	0.01
Orthophosphorus (mg/l P)*	7	9.7	26	68	0.01
Total Organic Carbon (mg/l)	1	14	-	14	-
Total Inorganic Carbon (mg/l)	0	-	-	-	-
Cyanide (mg/l)	3	0.00	0.00	0.00	0.00
Sulfide (mg/l)*	5	0.06	0.05	0.1	0.0
Hardness (mg/l Ca, Mg)	7	200	51	270	140
Noncarbonate Hardness (mg/l)	7	55	24	97	29
Calcium (mg/l)*	7	50	12	67	35
Magnesium (mg/l)*	7	18	6	27	12
Sodium (mg/l)*	7	35	18	60	17
Sodium Adsorption Ratio	7	1.0	0.4	1.7	0.6
% Sodium	7	26	5	34	18
Potassium (mg/l)*	7	1.7	0.4	2.2	1.2
Chloride (mg/l)*	7	17	9.6	35	8.9
Sulfate (mg/l)*	7	100	46	180	59
Fluoride (mg/l)*	7	0.21	0.04	0.3	0.2
Bromide (mg/l)	5	0.0	0.1	0.4	0.0
Silica (mg/l)*	7	11	4.7	15	1.0
Arsenic (mg/l)*	3	0.0010	0.0010	.002	0.001
Barium (mg/l)*	4	0.058	0.068	.130	0.000
Beryllium (mg/l)*	2	0.000	-	0.000	-
Bismuth (mg/l)*	1	0.002	-	<0.002	-
Boron (mg/l)*	5	0.051	0.025	0.090	0.025
Cadmium (mg/l)*	4	0.0008	-	<0.003	-
Chromium (mg/l)*	4	0.0005	-	<0.002	-
Cobalt (mg/l)*	4	<0.00075	-	<0.002	-
Copper (mg/l)*	4	0.0025	0.0022	0.005	0.001
Iron (mg/l)*	4	0.040	0.023	0.060	0.020
Lead (mg/l)*	4	<0.0005	0.0010	<0.002	0.000
Manganese (mg/l)*	4	0.0010	0.0020	0.004	0.00
Mercury (mg/l)*	3	0.000	0.0000	0.0000	0.0000
Molybdenum (mg/l)*	4	0.0023	0.0010	0.003	0.001
Nickel (mg/l)*	4	0.0033	0.0017	0.005	0.001
Silver (mg/l)*	2	0.000	0.000	0.000	0.000
Strontium (mg/l)*	2	0.210	0.212	0.360	0.060
Vanadium (mg/l)*	4	0.0016	0.0009	0.0025	0.0004
Zinc (mg/l)*	4	0.0003	0.011	0.020	0.00
Tin (mg/l)*	1	<0.002	-	<0.002	-
Aluminum (mg/l)*	4	0.040	0.034	0.090	0.020
Gallium (mg/l)*	1	0	-	0	-
Germanium (mg/l)*	1	<0.002	-	<0.002	-
Lithium (mg/l)*	4	0.0063	0.0095	0.020	0.00
Selenium (mg/l)*	3	0.0007	0.0006	0.001	0.000
Titanium (mg/l)*	1	0.006	-	0.006	-
Zirconium (mg/l)*	1	<0.003	-	<0.003	-
Gross Beta (mg/l Cs_{137})*	3	4.8	1.1	6.0	4.1
Chlorophyll A (mg/l)	3	0.0030	0.0021	0.0054	0.0018
Chlorophyll B (mg/l)	3	0.0026	0.0012	0.0035	0.0012
Phenols (mg/l)	5	0.0048	0.0008	0.006	0.004
Dissolved Solids (mg/l)*	6	310	90	462	223
Gross Alpha (mg/l U)*	3	<0.0078	0.0030	0.010	<0.0043
Gross Beta (mg/l SR_{90}/Y_{90})*	3	3.8	0.9	4.9	3.2
Dissolved Oxygen	See text for information.				

*Elements analyzed only for dissolved fraction.

Dissolved oxygen concentrations in the White River averaged 91 percent of saturation and exceeded 6 milligrams per liter (mg/l) 98 percent of the time. None of the concentrations measured would restrict the use of the White River for irrigation, aquatic life, or for drinking water (Ref. 24). Although phenol concentrations slightly exceeded drinking water criteria, the White River should not be rejected as a potable water supply, unless a better source is found.

In addition to the dissolved elements, suspended and settleable solids (which are measured by sediment analysis) constitute a large portion of the stream load. Table 2.3-3 shows the concentration of suspended sediment in the White River.

Evacuation Creek. The water quality of Evacuation Creek is quite different from that of the White River. Summaries of the sampling results for the station of Evacuation Creek at Watson, which had the same character but higher levels than the other two Evacuation Creek stations, are given in Tables 2.3-4 and 2.3-5. It appears that Evacuation Creek is sustained

Table 2.3-3

SUSPENDED SEDIMENT CONCENTRATIONS
IN THE WHITE RIVER (mg/l)[a]

	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
Base Flow Period October 1, 1974 to May 4, 1975	135	417	432	2,300	23
High Flow Period May 5, 1975 to August 4, 1975	41	3,127	2,160	8,910	391

(a) Preliminary, and not weighted by rate of flow.

Table 2.3-4

SUMMARY OF WATER QUALITY
EVACUATION CREEK AT WATSON (S-6)
Base Flow Period: September 1974 through February 1975

	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (°C)	9	4.0	3.7	10.5	.8
Turbidity (JTU)	6	11.5	11.3	30	3
Conductance (μmhos)	9	5,616	387	6,170	5,000
Chemical Oxygen Demand (mg/l)	9	44	7.6	59	34
pH (pH Units)	4	7.9	0.3	8.2	7.7
Carbon Dioxide (mg/l)	4	13.1	8.0	21	5.8
Alkalinity (mg/l $CACO_3$)	9	472	27	527	434
Bicarbonate (mg/l HCO_3)	9	575	33	642	525
Carbonate (mg/l CO_3)	9	0	0	0	0
Filterable Residue (mg/l)	4	4,900	748	5,900	4,100
Oil and Grease (mg/l)	4	4	3	8	0
Ammonia (mg/l N)*	9	.06	.03	.13	.02
Nitrite (mg/l N)*	9	.01	.01	.03	.00
Nitrate (mg/l N)*	8	.49	.65	1.6	.00
Kjeldahl Nitrogen (mg/l N)	9	.81	.12	1.0	.63
$NO_2 + NO_3$ (mg/l N)*	9	.44	.62	1.6	.00
Orthophosphate (mg/l PO_4)*	9	.04	.03	.09	.00
Phosphorus (mg/l)	9	.08	.15	.48	.01
Orthophosphorus (mg/l P)*	9	.01	.01	.03	.00
Total Organic Carbon (mg/l)	2	22	1	22.0	21.0
Total Inorganic Carbon (mg/l)	1	90	–	–	–
Cyanide (mg/l)	5	0	0	.00	.00
Sulfide (mg/l)*	9	.1	.1	.3	.0
Hardness (mg/l Ca, Mg)	9	1,400	112	1,600	1,300
Noncarbonate Hardness (mg/l)	9	923	102	1,100	820
Calcium (mg/l)*	9	214	14	240	200
Magnesium (mg/l)*	9	209	25	250	170
Sodium (mg/l)*	9	972	71	1,100	860
Sodium Adsorption Ratio	9	11	1	12.0	10.0
% Sodium	9	60	2	62	58
Potassium (mg/l)*	9	8	3	11.0	2.2
Chloride (mg/l)*	9	66	9	87	56
Bromide (mg/l)	9	0.4	0.1	0.4	0.2
Sulfate (mg/l)*	9	2,889	247	3,300	2,600
Fluoride (mg/l)*	9	.9	.1	1.1	.8
Silica (mg/l)*	9	10	1	11	8.8
Arsenic (mg/l)*	5	3	1	5	1
Barium (mg/l)*	5	<.1	–	<.1	–
Beryllium (mg/l)*	2	<.01	–	<.01	–
Bismuth (mg/l)*	1	.09	–	<.09	–
Boron (mg/l)*	5	1.95	.95	2.7	.31
Cadmium (mg/l)*	5	<.001	–	<.001	–
Chromium (mg/l)*	5	<.012	–	.02	–
Cobalt (mg/l)*	5	<.003	–	.003	–
Copper (mg/l)*	5	.004	.002	.007	.003
Iron (mg/l)*	5	.026	.015	.050	.01
Lead (mg/l)*	5	<.002	–	<.002	–
Manganese (mg/l)*	5	.127	.061	.21	.067
Mercury (mg/l)*	5	<.00002	–	<.0001	–
Molybdenum (mg/l)*	5	.036	.008	.045	.024
Nickel (mg/l)*	5	.011	.006	.018	.004
Silver (mg/l)*	2	<.001	–	.001	–
Strontium (mg/l)*	2	4.2	.14	4.3	4.1
Vanadium (mg/l)*	4	<.003	–	.0042	–
Zinc (mg/l)*	5	.014	.005	.020	.010
Tin (mg/l)*	1	<.09	–	<.09	–
Aluminum (mg/l)*	5	<.01	–	.01	–
Gallium (mg/l)*	1	<.04	–	<.04	–
Germanium (mg/l)*	1	<.09	–	<.09	–
Lithium (mg/l)*	5	.110	.010	.12	.10
Selenium (mg/l)*	5	<.003	–	.003	–
Titanium (mg/l)*	1	<.060	–	<.06	–
Zirconium (mg/l)*	1	<.15	–	<.15	–
Gross Beta (mgl Cs_{137})*	4	.062	.072	.17	.020
Chlorophyll A (mg/l)	4	.0011	.0006	.0018	.0004
Chlorophyll B (mg/l)	4	.0015	.0012	.003	.000
Phenols (mg/l)	9	<.002	–	.007	–
Dissolved Solids (mg/l)*	9	4,948	360	5,620	4,500
Gross Alpha (mg/l Ul*	4	.09	–	<.02	–
Gross Beta (mg/l SR_{90}/Y_{90})*	4	.05	.06	.14	.018
Dissolved Oxygen	See text for information.				

*Elements analyzed only for dissolved fraction.

Table 2.3-5

SUMMARY OF WATER QUALITY
EVACUATION CREEK AT WATSON (S-6)
High Flow Period: March through August 1975

	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
Temperature (°C)	10	15.2	9.7	28.2	0.8
Turbidity (JTU)	10	1432	2118	6800	26
Conductance (μmhos)	10	4116	1002	5140	1650
Chemical Oxygen Demand (mg/l)	10	77	92	330	32
pH (pH Units)	8	8.3	0.3	8.8	7.9
Carbon Dioxide (mg/l)	8	4.0	3.1	11	1.1
Alkalinity (mg/l $CACO_3$)	10	334	105	459	128
Bicarbonate (mg/l HCO_3)	10	399	145	559	129
Carbonate (mg/l CO_3)	10	4.2	13	42	0
Filterable Residue (mg/l)	5	3180	1221	4200	1300
Oil and Grease (mg/l)	9	8.0	17	52	1
Ammonia (mg/l N)*	10	0.018	0.015	0.04	0.00
Nitrite (mg/l N)*	10	0.012	0.016	0.05	0.00
Nitrate (mg/l N)*	10	1.3	0.6	2.2	0.06
Kjeldahl Nitrogen (mg/l N)	10	2.1	2.1	7.9	0.96
NO_2 + NO_3 (mg/lN)*	10	1.3	0.6	2.2	0.09
Orthophosphate (mg/l PO_4)*	10	0.05	0.05	0.12	0.00
Phosphorus (mg/l)	10	1.2	1.6	4.7	0.01
Orthophosphorus (mg/l P)*	10	0.017	0.017	0.04	0.00
Total Organic Carbon (mg/l)	2	21	18	34	8.2
Total Inorganic Carbon (mg/l)	0	-	-	-	-
Cyanide (mg/l)	6	0.007	0.004	0.02	0.00
Sulfide (mg/l)*	10	0.08	0.10	0.3	0.0
Hardness (mg/l Ca, Mg)	10	992	272	1400	340
Noncarbonate Hardness (mg/l)	10	656	181	910	220
Calcium (mg/l)*	10	140	34	200	73
Magnesium (mg/l)*	10	155	46	210	39
Sodium (mg/l)*	10	676	196	980	230
Sodium Adsorption Ratio	10	9.2	1.7	12	5.4
% Sodium	10	59.5	1.7	61	56
Potassium (mg/l)*	10	7.1	2.0	12	3.4
Chloride (mg/l)*	10	39	11	63	18
Sulfate (mg/l)*	10	1998	599	3000	680
Fluoride (mg/l)*	10	0.8	0.2	1.0	0.5
Bromide (mg/l)	10	0.3	0.1	0.4	0.2
Silica (mg/l)*	10	10.6	3.5	17	6.3
Arsenic (mg/l)*	6	0.0017	0.001	0.003	0.000
Barium (mg/l)*	8	< 0.057	-	< 0.100	-
Beryllium (mg/l)*	5	< 0.048	0.0039	0.010	0.0
Bismuth (mg/l)*	3	0.023	-	< 0.040	-
Boron (mg/l)*	8	0.939	0.753	2.600	0.210
Cadmium (mg/l)*	8	0	0	0	0.000
Chromium (mg/l)*	8	< 0.0046	-	< 0.020	-
Cobalt (mg/l)*	8	< 0.0031	-	< 0.020	-
Copper (mg/l)*	8	0.007	0.0033	0.012	0.003
Iron (mg/l)*	8	0.080	0.068	0.22	0.02
Lead (mg/l)*	8	< 0.0038	-	< 0.020	-
Manganese (mg/l)*	8	< 0.024	0.032	0.10	0.00
Mercury (mg/l)*	6	0	0	0	0.0000
Molybdenum (mg/l)*	8	0.027	0.010	0.043	0.019
Nickel (mg/l)*	8	< 0.0049	0.0065	0.020	0.000
Silver (mg/l)*	5	< 0.001	0.0014	0.003	0.000
Strontium (mg/l)*	5	2.800	1.433	4.200	1.200
Vanadium (mg/l)*	8	< 0.0041	-	< 0.020	-
Zinc (mg/l)*	8	0.013	0.013	0.040	0.010
Tin (mg/l)*	3	< 0.023	-	< 0.040	-
Aluminum (mg/l)*	8	0.047	0.046	0.130	0.010
Gallium (mg/l)*	3	< 0.0073	-	< 0.010	-
Germanium (mg/l)*	3	< 0.021	-	< 0.030	-
Lithium (mg/l)*	8	0.067	0.033	0.120	0.020
Selenium (mg/l)*	6	0.0025	0.0015	0.004	0.000
Titanium (mg/l)*	3	< 0.018	0.014	0.030	< 0.003
Zirconium (mg/l)*	3	< 0.033	0.021	< 0.050	< 0.010
Gross Beta (pc/l Cs_{137})*	5	< 19	4	26	7
Chlorophyll A (mg/l)	5	0.005	0.008	0.019	0.0000
Chlorophyll B (mg/l)	5	0.0017	0.0018	0.004	0.0000
Phenols (mg/l)	10	0.0054	0.0066	0.024	0.001
Dissolved Solids (mg/l)*	10	3438	981	4920	1170
Gross Alpha (mg/l U)*	5	< 0.043	0.010	0.067	0.016
Gross Beta (pc/l SR_{90}/Y_{90})*	5	<17	3	20	<14
Dissolved Oxygen	See text for information.				

*Elements analyzed only for dissolved fraction.

by groundwater seepage for all but a very few days of the year. Snowmelt and rainfall runoff contribute large volumes of water, but the duration of this flow is very short (Figure 2.3-2).

Over the one year study period, coliform levels ranged from 12/100 ml to 530/100 ml, and pesticide and herbicide levels were below detection. Dissolved oxygen concentrations in Evacuation Creek averaged 91 percent of saturation and exceeded 6 mg/l 89 percent of the time. Suspended sediment levels showed wide variation, as summarized in Table 2.3-6.

Dissolved solids and sulfates were considerably above the levels suggested for either irrigation or drinking water. Of the trace elements measured in Evacuation Creek, boron, manganese, and molybdenum regularly exceeded one or more water quality criteria (Ref. 25).

Table 2.3-6

SUSPENDED SEDIMENT CONCENTRATIONS IN EVACUATION CREEK (mg/l)[a]

	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
Base Flow Period October 1, 1974 to February 28, 1975	46	91	76	280	7
High Flow Period March 1, 1975 to August 31, 1975	87	12,954	71,629	658,000	8

(a) Preliminary, and not weighted by rate of flow.

The predominant dissolved solids in Evacuation Creek are sodium and sulfate ions. The quality of water in Evacuation Creek on Tract U-b is similar to the quality of groundwater from the Bird's Nest Aquifer.

Southam Canyon, Asphalt Wash, and Hells Hole Canyon. Flows in these washes are very irregular and of short duration. Table 2.3-7 lists the results of the quality samples collected from these wastes during 1975. No samples were collected from the dry wastes of Southam Canyon.

2.3.2 SYSTEM INTERACTIONS

There are three interacting water systems within the study area:

- White River
- Bird's Nest Aquifer
- Evacuation Creek

The flow of the White River changes very little across the study area, such that flow gains and water quality changes, caused by ground or surface water inflow, are difficult to discern. Evacuation Creek, the only consistent surface flow into the White River from the tracts, averaged less than 1 cfs near its mouth during the baseflow period, and is supplied almost completely by groundwater seepage from the Bird's Nest Aquifer below Watson.

2.3.3 GROUNDWATER

2.3.3.1 Occurrence

Groundwater occurs throughout the region in alluvial deposits along major stream courses, and throughout the Green River, Wasatch, and Mesa Verde Formations (Ref. 26). The Green River Formation, and especially its uppermost member, the Parachute Creek Member, contains the principal oil shale zone. Most of the deeper drilling on the

Table 2.3-7

WATER QUALITY RESULTS FROM THE WASHES – 1975

	Hell's Hole Canyon at Mouth (S-5)		Asphalt Wash at Mouth (S-12)
	July 16	August 18	August 14
Temperature (°C)	–	–	–
Turbidity (JTU)	–	190	2,300
Conductance (μmhos)	2,020	–	–
Chemical Oxygen Demand (mg/l)	–	–	–
pH (pH Units)	–	–	–
Carbon Dioxide (mg/l)	–	–	–
Alkalinity (mg/l $CACO_3$)	189	93	189
Bicarbonate (mg/l HCO_3)	231	113	230
Carbonate (mg/l CO_3)	–	–	–
Filterable Residue (mg/l)	–	–	–
Oil and Grease (mg/l)	–	–	–
Ammonia (mg/l N)*	–	0.00	0.00
Nitrite (mg/l N)*	–	0.12	0.06
Nitrate (mg/l N)*	–	0.77	3.4
Kjeldahl Nitrogen (mg/l N)	–	1.5	4.4
$NO_2 + NO_3$ (mg/l N)*	0.04	0.89	3.5
Orthophosphate (mg/l PO_4)*	0.00	0.00	0.34
Phosphorus (mg/l)	–	0.07	5.9
Orthophosphorus (mg/l P)*	0.00	0.00	0.11
Total Organic Carbon (mg/l)	–	–	–
Total Inorganic Carbon (mg/l)	–	–	–
Cyanide (mg/l)	–	–	–
Sulfide (mg/l)*	–	0.2	0.2
Hardness (mg/l Ca, Mg)	810	290	68
Noncarbonate Hardness (mg/l)	620	200	0
Calcium (mg/l)*	260	84	19
Magnesium (mg/l)*	38	19	4.9
Sodium (mg/l)*	160	39	84
Sodium Adsorption Ratio	2.5	1.0	4.4
% Sodium	30	22	71
Potassium (mg/l)*	11	7	5.5
Chloride (mg/l)*	9.0	4.1	12
Sulfate (mg/l)*	950	260	34
Fluoride (mg/l)*	0.4	0.4	0.5
Silica (mg/l)*	15	7.5	14
Arsenic (mg/l)*	–	1	37
Barium (mg/l)*	–	–	–
Beryllium (mg/l)*	–	–	–
Bismuth (mg/l)*	–	–	–
Boron (mg/l)*	210	90	0.280
Cadmium (mg/l)*	–	–	–
Chromium (mg/l)*	–	–	–
Cobalt (mg/l)*	–	–	–
Copper (mg/l)*	–	0.017	0.045
Iron (mg/l)*	0.420	0.070	0.240
Lead (mg/l)*	–	–	–
Manganese (mg/l)*	0.520	–	–
Mercury (mg/l)*	–	0.0000	0.0000
Molybdenum (mg/l)*	–	–	–
Nickel (mg/l)*	–	–	–
Silver (mg/l)*	–	–	–
Strontium (mg/l)*	–	0.890	0.340
Vanadium (mg/l)*	–	–	–
Zinc (mg/l)*	–	0.130	0.120
Tin (mg/l)*	–	–	–
Aluminum (mg/l)*	–	0.000	0.090
Gallimum (mg/l)*	–	–	–
Germanium (mg/l)*	–	–	–
Lithium (mg/l)*	–	0.010	0.040
Selenium (mg/l)*	–	0.002	0.001
Titanium (mg/l)*	–	–	–
Zirconium (mg/l)*	–	–	–
Gross Beta (mg/l Cs_{137})*	–	–	–
Chlorophyll A (mg/l)	–	–	–
Chlorophyll B (mg/l)	–	–	–
Phenols (mg/l)	–	–	–
Dissolved Solids (mg/l)*	–	500	351
Gross Alpha (mg/l U)*	–	–	–
Gross Beta (mg/l SR_{90}/Y_{90})*	–	–	–

*Elements analyzed only for dissolved fraction.

tracts was done to investigate this zone. Data on the deeper horizons on and around the tracts are available on geophysical logs of oil and gas test wells (Table 2.3-8).

2.3.3.2 Aquifers

The Bird's Nest Aquifer, the principal aquifer investigated in the region, is described (Ref. 27) as a "stratigraphic unit near the top of the Green River Formation." In this aquifer, many cavities occur in a zone of the upper part of the Evacuation Creek Member.* Some of these cavities contain secondary calcite and are believed to have been formed by the leaching of nahcolite from the marlstone. The zone is locally called the "Bird's Nest Zone" and is well developed near the mouth of Evacuation Creek.

Before leaching formed it into an aquifer, the "Bird's Nest Zone" consisted of nahcolite nodules set in marlstone. The zone is very persistent laterally and vertically throughout the area investigated. The upper surface of the aquifer slopes to the northwest uniformly at approximately 250 feet per mile, as shown in Figure 2.3-3. As seen in Table 2.3-8, the thickness of the aquifer ranges from 90 to about 205 feet and averages about 115 feet. On electric logs, the physical appearance of the aquifer is uniform throughout the area investigated and consists of two zones of high resistivity separated by an interval of low resistivity. The low resistivity zone commonly occurs in the upper third of the aquifer and is usually 15 to 20 feet thick. The upper high-resistivity zone is a sandstone believed to be correlative to the horse bench sandstone of Cashion (Ref. 19); the lower high-resistivity zone is attributed to solution cavities and fracturing.

*Cashion (1974) dropped the term "Evacuation Creek Member" and extended the term "Parachute Creek Member" to include the top of the Green River Formation.

Table 2.3-8

BIRD'S NEST AQUIFER DATA SOUTH-EAST UINTA BASIN, UTAH

Well No.	Well Location	Surface Elevation* (ft)	Aquifer Interval (Depth in ft)	Aquifer Thickness (ft)	Elevation* at top of Aquifer	Well Depth	Well Registrant	Data Available in Aquifer Zone							
								Electric Log	Gamma Ray	Neutron	Caliper	Formation Density	Sonic	Temp	Flow
2	C NW SE 24-95/23E	5,645	1,356 - 1,478	122	4,289	7,236	Pacific Nat. Gas	X	X	X	X	X	X		
3	NW SE 02-105/23E	5,461	1,545 - 1,660	115	3,916	5,226	Humble Oil		X	X					
4	NW NE NE 11-105/23E	5,492	1,430 - 1,520	90	4,062	5,049	El Paso Nat. Gas Co.	X							
5	NE NE NW 14-105/23E	5,537	1,345 - 1,550	205	4,242	8,502	Gulf Oil Corp.	X	X	X					
6	NE NE SE 15-105/23E	5,613	1,410 - 1,575	165	4,203	7,418	El Paso Nat. Gas Co.	X	X	X					
7	NW NW 24-105/23E	4,932	520 - 640	120	4,412	6,436	Shell Oil Co.	X	X				X		
8	NE NE 36-105/23E	±5,078	370 - 590	130	4,708	924	Shell Oil Co.	X							
9	NE SW 03-105/23E	5,334	1,415 - 1,535	120	3,919	5,858	Belco Pct. Corp	X					X		
10	NW NE SE 30-105/24E	5,294	602 - 710	108	4,692	1,141	White River Shale	X	X	X	X	X	X	X	X
11	SW SE 28-105/24E	5,392	514 - 620	106	4,878	7,048	El Paso Nat. Gas	X			X				
12	NE NE 29-105/24E	5,260	542 - 660	118	4,718	6,030	El Paso Nat. Gas	X			X				
13	C NE SW 32-105/24E	±5,460	610 - 715	105	4,870	7,033	Shell Oil Co.	X					X		
14	NE SW 22-105/24E	5,292	490 - 605	115	4,802	6,161	Moab Drilling Co.	X			X		X		
15	S/2 SW SW 14-105/24E	5,242	408 - 522	114	4,834	958	White River Shale	X	X	X	X	X	X	X	X
16	SW NW 14-105/24E	5,417	380 - 515	135	5,037	4,249	Continental Oil Co.	X	X	X					
20	NW NW SW 02-115/23E	5,550	620 - 740	120	4,930	8,038	Gen. Pet. & Stanolind	X							
22	NW SE 11-115/23E	5,989	890 - 1,000	110	5,099	5,901	Shamrock Oil & Gas Co.	X							
23	SW SE 13-115/23E	5,617	325 - 455	130	5,292	5,863	Shamrock Oil & Gas Co.	X							
24	SE NW 14-115/23E	5,958	875 - 1,000	125	5,083	6,649	Shamrock Oil & Gas Co.	X							
25	SE SE 10-115/23E	5,849	762 - 900	138	5,087	7,384	Shamrock Oil & Gas Co.	X							
28	NE SW 13-115/24E	5,567	275 - 400	125	5,292	5,581	Shamrock Oil & Gas Co.	X							
29	SE SE 15-115/23E	6,076	872 - 970	98	5,204	6,467	Shamrock Oil & Gas Co.	X							
30	NE SW 03-115/24E	5,270	211 - 310	99	5,059	2,521	Shamrock Oil & Gas Co.	X							
X-9	NW SE NW 27-105/24E	5,427	553 - 651	98	4,874	1,068	White River Shale	X	X	X	X	X	X	X	X
G-19	SE NE NW 14-113/24E	5,832	190 - 325	135	5,642	800	White River Shale		X	X	X	X			
X-2	NW NE NW 14-105/24E	4,954	213 - 326	113	4,771	766	White River Shale	X	X	X	X	X		X	X
P-3	SE SE SW 25-105/24E	5,498	370 - 480	110	5,123	711	White River Shale	X	X	X	X	X		X	X
P-1	NE SE SW 12-105/24E	5,284	300 - 435	135	4,984	1,225	White River Shale	X	X	X	X	X		X	X
X-3	C NE NW 13-105/25E	5,295	90 - 260	170	5,205	586	White River Shale	X	X	X	X	X	X	X	X
X-6	C NW 19-105/25E	5,472	274 - 379	105	5,198	806	White River Shale	X	X	X	X	X	X	X	X
P-4	NE SE SE 19-105/25E	5,719	345 - 482	136	5,343	1,170	White River Shale		X	X	X	X			
HS-4	NW NE NW 20-105/24E	5,061	495 - 667	172	4,566	1,076	Gulf Oil Corp.	X	X	X					
P-2	NW NE NE 20-105/24E	4,991	404 - 500	96	4,587	1,290	White River Shale	X	X	X	X	X	X	X	X

*Feet above mean sea level.

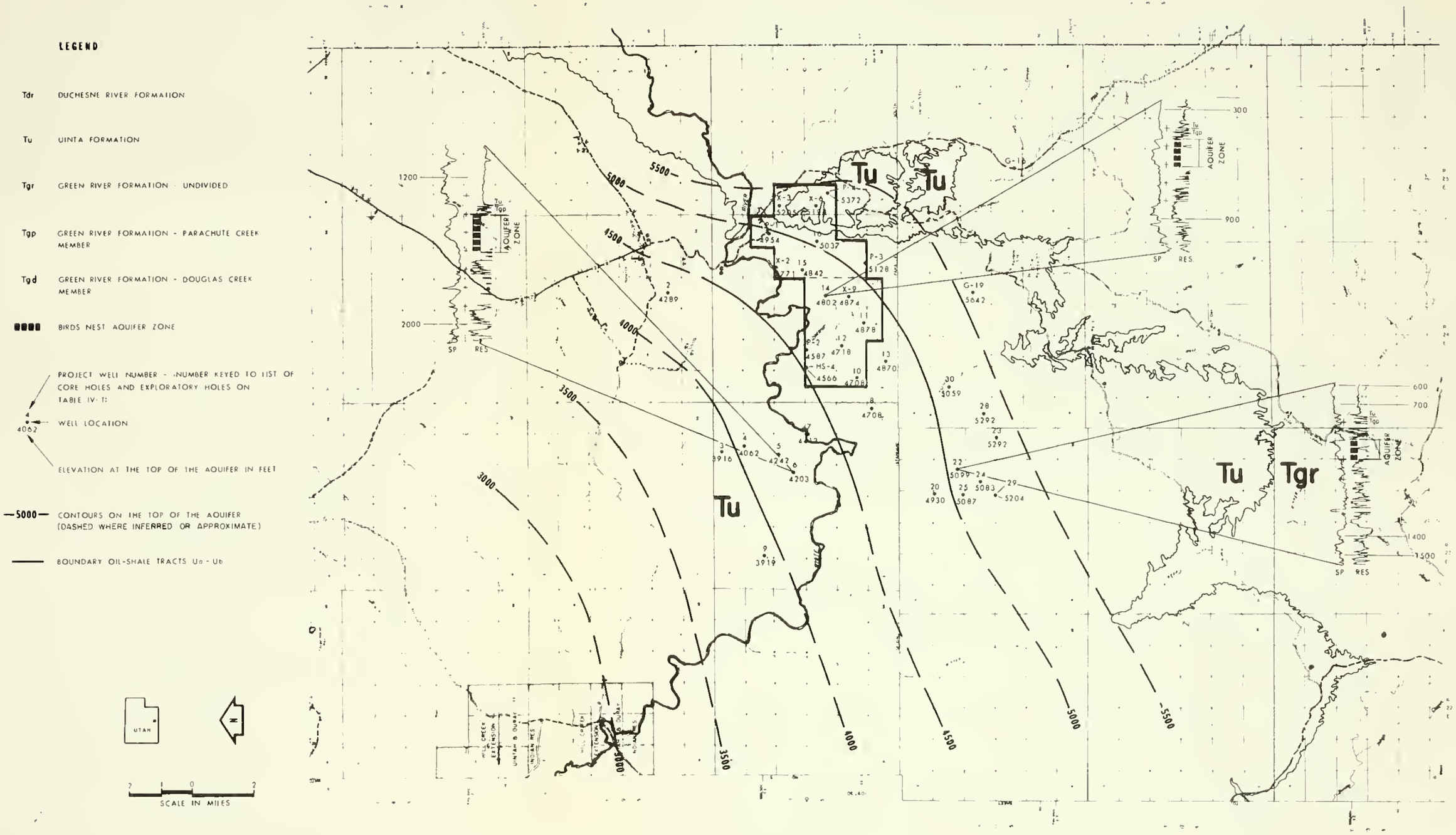

Figure 2.3-3. Bird's Nest Aquifer Structural Elevations

The stratigraphic position of the aquifer is as predictable as its physical properties. The aquifer may be expected to occur in the top 50 to 125 feet of the Green River Formation and is at an average of 430 feet above the Mahogany Marker.

No off-tract water production figures were found for the Bird's Nest Aquifer within the area of investigation, but flume-measured flow rates during drilling on the tracts ranged from 0 to 700 gallons per minute (gpm) and averaged about 30 gpm. The wide range in production reflects in part the degree of aquifer saturation, which is nearly dry at Hole P-3 (south border of U-b) and is dry at Hole G-19 (3 miles south of U-b).

Beginning at Hole P-3, the aquifer becomes increasingly saturated toward the northwest and attains a hydrostatic head of about 240 feet at Hole P-2 (north border at U-a), where the highest rate of water production, 700 gpm, was measured during drilling. As is discussed in Subsection 2.3.3.8, the quality of the Bird's Nest Aquifer water restricts its use for many processes and applications.

Aquifer tests were conducted at Test Sites P1 (north border of U-b), P2, and P3 to determine the aquifer constants of transmissivity and storage coefficient. Drawdown and recovery were monitored in the pumped well and at two observation wells on each test site and provide the basis for the determination of aquifer constants. Table 2.3-9 summarizes the aquifer constants determined from the testing program. The site of the P-2 upper well is completed and opens another aquifer, and is the only location on the tracts where that aquifer has been encountered. The base of this small aquifer lies just 75 feet above the top of the Bird's Nest Aquifer (P-2 lower), but no interconnection between it and P-2 lower was noted during the pumping.

Table 2.3-9

SUMMARY OF AQUIFER CONSTANTS

	Well Number			
	P-1	P-2 upper	P-2 lower	P-3
Static Water Level (ft)	278.6	99.8	157.8	496.2
Depth to Top of Aquifer (ft)	300	297	404	370
Pumping Rate (gpm)	45	10	550	3
Transmissivity (gpd/ft)	1,500	150	75,000	15
Storage Coefficient	3.52×10^{-4}	1.34×10^{-5}	6.01×10^{-5}	0.10
Test Period (hr)	75.0	27.9	146.1	0.5

2.3.3.3 Groundwater Recharge

The outcrop of the Green River Formation is shown on the geologic map (Figure 2.2-3). The Bird's Nest Aquifer is approximately 50 to 125 feet below the upper contact of the Green River Formation. Therefore, the location of the aquifer can be assumed to occupy approximately the same position as the contact on the geologic map.

South of the junction of U.S. 40 and Utah 45, the aquifer dips steeply along its northern edge at the rate of 1,000 to 1,500 feet per mile. In these areas of steep dip, the aquifer is upturned against the ground surface slope (Ref. 28). Under these conditions, exposures of the aquifer would be excellent for recharge from direct precipitation, snowmelt, and runoff. Field inspection suggests that if the Bird's Nest Aquifer is present in this area, it is covered by the Duchesne River Formation. Conditions are not ideal for significant direct recharge around and south of the tracts, because the aquifer dip is not known to exceed 300 feet per mile; hence the aquifer is usually exposed in canyons on nearly vertical walls. Unfortunately, no data are available to estimate

total basin recharge to the Bird's Nest Aquifer. Water level fluctuations have been recorded and do indicate periods of recharge and discharge, but insufficient data are available to make generalizations about the entire aquifer system. Where the aquifer is in contact with alluvium in the bottoms of Evacuation and Bitter Creeks, Asphalt Wash, Hells Hole Canyon, and the White River, the potential for recharge is enhanced. While this may be true of other major and minor drainages in the region, both Evacuation Creek and the White River are known to receive water from the aquifer.

2.3.3.4 Groundwater Movement

Because data for the water level beyond the tract boundaries are not available, it can only be speculated that recharge water migrates along the northwest-dipping aquifer from the north, east, and south, to be discharged eventually at known points along the White River below Evacuation Creek and along the entirety of Evacuation Creek across Tract U-b. Additional points of discharge may occur along other major drainage courses, such as Bitter and Sweetwater Creeks and the Green River.

The site-specific water-level contours provide clear evidence that the groundwater slopes in the same direction as the geologic structure (Figure 2.3-4). These contours also indicate the importance of the White River as a groundwater pressure sink about 1.5 miles east of the Watson bridge. The somewhat steeper gradient and the departure from the prevailing northwesterly flow direction combine to imply the presence of discharge from the aquifer to the White River.

On the basis of present baseline data, intraformational or interformational leakage is not expected to be significant, since the major aquifer zones appear to be well shielded from one another by extensive thicknesses of shaly material.

2.3.3.5 Groundwater Discharge

Discharge from the aquifer, in the form of seeps and springs, is common along the down-dip portions of the aquifer on the east wall of Hells Hole and Evacuation Creek Canyons. The same is true of the large patch of isolated aquifer in the northeast portions of T11S, R25E southeast of U-b. The water in these areas is intercepted by Evacuation Creek Canyon before it can continue its westward migration into the central part of the basin.

The tracts are near the southeastern edge of a large groundwater reservoir beneath the Uinta Basin, and the groundwater surface grades from a dry aquifer near the southeast edge of Tract U-b to high artesian pressures at the northwest edge of Tract U-a. The approximate horizon at which the aquifer is dry is shown in Figure 2.3-4. The line conforms roughly to a structural elevation of about 5,200 feet above mean sea level. Near the southern boundary of Tract U-b, this elevation conforms to the aquifer discharge elevation in Evacuation Creek.

The aquifer is apparently under equilibrium conditions, and discharge equals recharge. The main body of the aquifer is full to capacity, as suggested by the presence of springs and seeps on the west side of Evacuation Creek beginning about a mile south of the southern boundary of Tract U-b and continuing intermittently to the confluence of the White River. Seepage is especially prevalent in the NW quarter of Section 13, T10S, R25E, SLB&M, where a flow of more or less consistent quality and quantity is provided to stream-gauging Site S-2. The aquifer is also in contact with the White River at an elevation of about 5,000 feet in the NE quarter of Section 12, T10S, R25E, and discharges to the river at this location, as evidenced by the presence of seeps along the wall of the canyon.

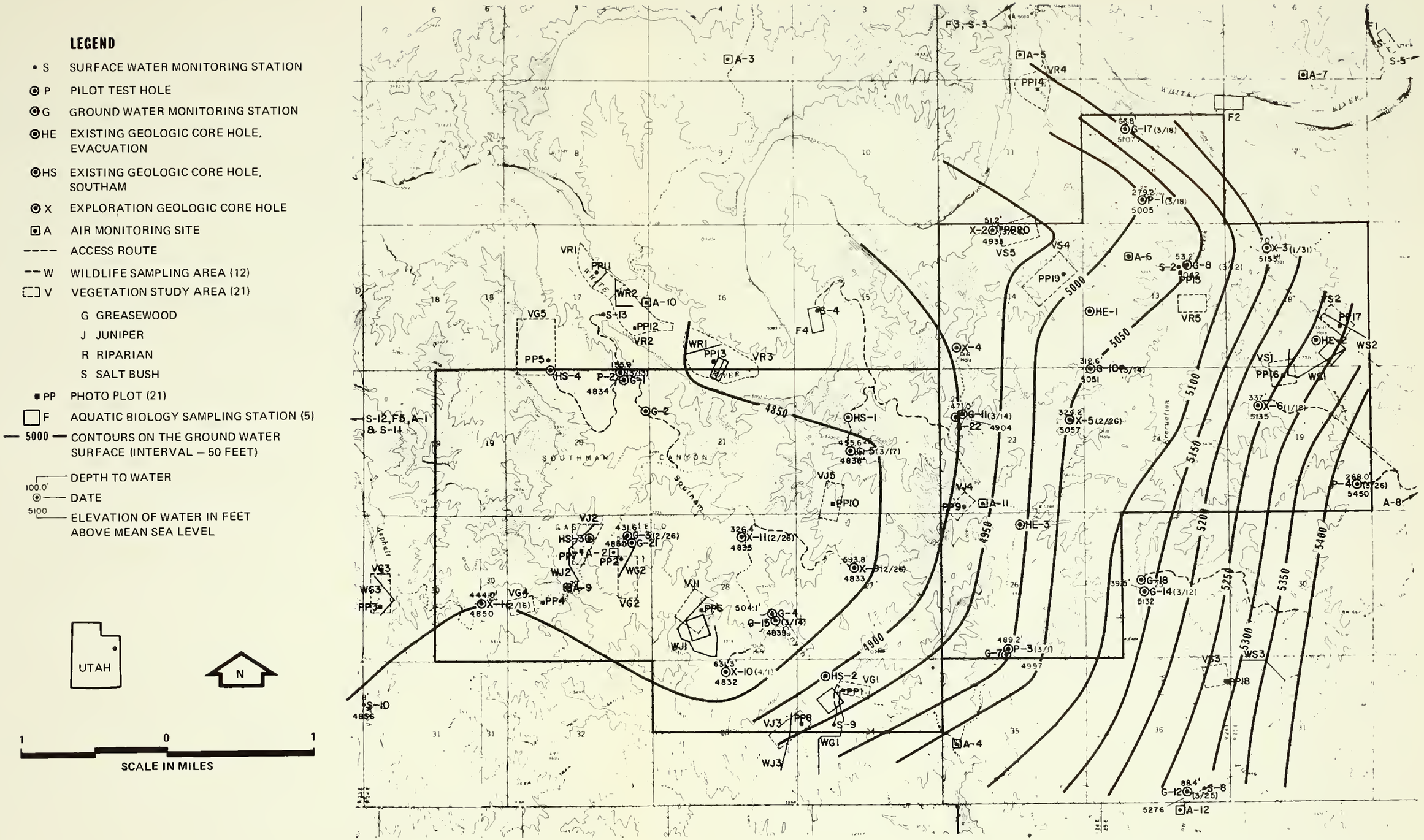

Figure 2.3-4. Contours on the Ground Water Surface of the Bird's Nest Aquifer, March 1975

In early May of 1975, a detailed investigation of the aquifer source and its water quality (as compared with surface water quality) was undertaken in Evacuation Creek Canyon from a location near Watson Site to the White River. During this period, the creek was flowing throughout this reach, presumably as a result of the snowstorms a few days earlier. The flow appeared to be constant and at an estimated rate of 1.5 to 2 cfs. Water temperature in the stream was highly variable, ranging from 48.4°F to 72.3°F, depending on air temperature and sun exposure of the creek bank. The specific conductance of the stream water and spring water maintained no consistent relationship. The temperature of the aquifer water ranged from 47.8°F to 65.8°F.

The Bird's Nest Aquifer is exposed at ground surface throughout Tract U-b within Evacuation Creek Canyon. Even though Evacuation Creek itself probably does not contribute much to the recharge of the aquifer, the entire surface drainage system leading down and across exposures of the aquifer represents a direct recharge area. No other points of discharge, from the main body of the underground reservoir, have been observed within the area of investigation.

2.3.3.6 Groundwater Fluctuations

Data are not available to determine the fluctuation of the water surface on a regional basis. The data that are available have been gathered as a part of the monitoring effort for this program (Figure 2.3-5).

The measured depths to water, along with the results of the continuous monitoring program, suggest that water levels did not fluctuate more than 10 feet over the period of record. The highest water levels recorded were in March 1975.

2.3.3.7 Groundwater Storage and Change in Storage

Groundwater in storage includes the saturated portion of the aquifer and any volume of water under artesian pressure. Table 2.3-10 summarizes the groundwater storage estimates for the tracts.

As previously noted, the elevation of the water surface fluctuates as a result of recharge and discharge. The data and observations available, however, suggest that as the water level rises, the discharge in Evacuation Creek (and presumably in the White River) increases. Thus, in its currently unstressed state, the level of the water surface in the Bird's Nest Aquifer is controlled more by the elevation of the discharge points than by the amount of recharge. Because of these conditions and as the available record suggests, it is assumed that the long-term change in storage is zero. The records available for the period January 15, 1975, through January 15, 1976, suggest that the average net change in the Bird's Nest Aquifer water level was +1.0 feet, including both artesian and water table responses.

2.3.3.8 Groundwater Quality

A comprehensive discussion of groundwater quality throughout the Uinta Basin is provided by Austin and Skogerboe (Ref. 26). Table 2.3-11 is a summary of the groundwater data available in that report and describes waters of the Mesa Verde, Wasatch, Green River, and Uinta Formations in terms of total dissolved solids (TDS). Available data suggest that the Green River Formation consistently contains the lowest TDS content of all the formations. Upon inspection of Figure 2.3-6, it may be seen that, in general, there is a decrease in groundwater quality towards the northwest.

Feltis (Ref. 29) suggested that the main area of aquifer recharge is along the northern and northwestern part of the basin and is indicated by the

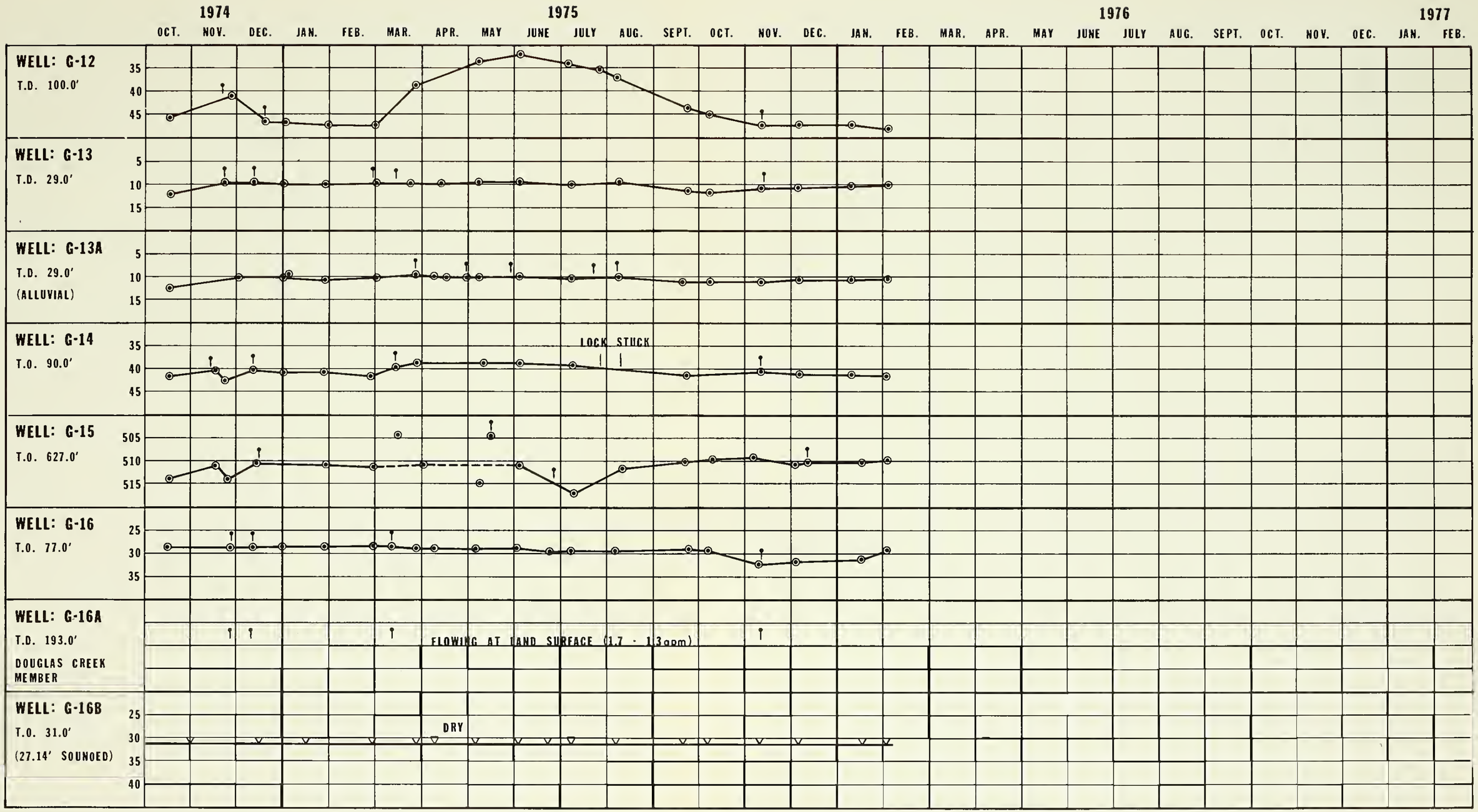

Figure 2.3-5. Water Levels in Wells

Table 2.3-10

GROUNDWATER IN STORAGE IN THE BIRD'S NEST AQUIFER
TRACTS U-a AND U-b UINTAH COUNTY, UTAH

Saturated thickness[a] (feet)	Area[b] (acres)	Groundwater in Storage[c] (acre-ft)
+350 (probably 375)	588.8	5,890
+325	480.0	4,802
+275	704.0	7,042
+225	1,011.2	10,114
+175	2,022.4	20,226
+125	1,683.2	16,833
75	1,555.2	11,664
25	1,280.0	3,200
0	902.4	0
	10,227.2	79,771

(a) If the value of thickness is preceded by a +, it includes artesian head and 100 feet of saturated thickness. If the value is less than 100, it represents the actual saturated thickness under water table conditions.

(b) Area determined by planimetry between contours on tract.

(c) For artesian head conditions, a storage coefficient of 1.8×10^{-5} was used; for the saturated aquifer, a specific yield value of 0.1 was used.

presence of good water quality. Since not all aquifers discussed crop out in these areas, only those that do will be subject to recharge from direct precipitation, snowmelt, or leakage from streams. Feltis ascribed to interformational leakage the presence of high-quality water in areas where the aquifers do not crop out. Electric well log data indicate that throughout the regional area of investigation the water-bearing zones of the Mesa Verde, Wasatch, and Green River Formations appear to be well

Table 2.3-11

GROUNDWATER QUALITY DATA IN THE UINTA BASIN, UTAH

Formation	Location (T/R)	Source	Yield (GPM)	Total Dissolved Solids (ppm)
Mesa Verde Group	9S/23E	–	–	12,511 - 62,502
	10S/24E (2)	Oil Well	1	
	12S/14E	Oil Well	–	
	17S/17E	Spring	–	707
	20S/20E (2)	Oil Well	–	660 - 1,090
Wasatch Formation	15S/21E	–		1,966
	1N/1E (USM)	–		1,302
	16S/17E	Spring	225 (Sept. 1948)	596
Green River Formation	11S/12E	Gas Well	0.5 - 200 gpm	619
	14S/20E	Oil Well		818
	15S/23E	Spring		381
	2N/2W (USM)	Oil Well		348 (from 4,115 ft)
	10S/20E-35	Gas Well	80 (flow)	–
	10S/22E-17	Gas Well	10 (flow)	–
	*9S/24E	Oil Well	220	– (from 1,932 ft)
Uinta Formation	7S/22E	Oil Well	–	2,365
	7S/24E	Oil Well	110	898
	9S/23E	Oil Well	30	81,200
	4S/5W (USM)	Oil Well	30	22,915
	1S/8W (USM)	Spring	50	237
	4S/7W (USM)	Spring	20	7,320
	5S/6W (USM)	Spring	200	1,840
	5S/7W (USM)	Spring	225	2,710
	2S/5W (USM)	Water Well	–	439
	3S/3W (USM)	Water Well	20	788
	3S/8W (USM)	Water Well	–	4,430

*Largest reported yield from the Green River formation in the Uinta Basin (Ref. 26).

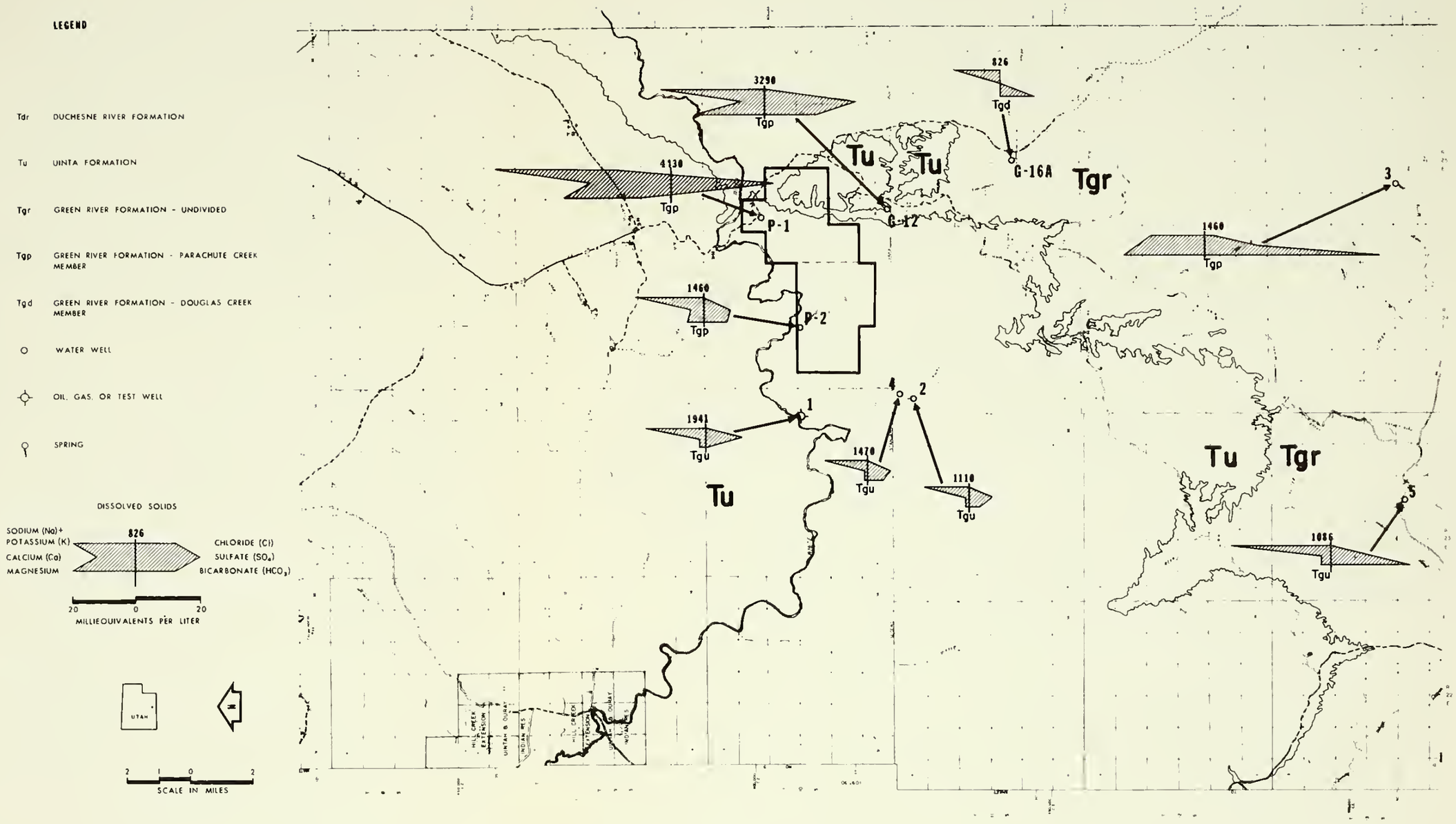

Figure 2.3-6. Stiff Diagrams of Regional Groundwater Quality

isolated from one another by shales. The subsurface extent of fracturing is not known, but surface fracture patterns are continuous through the upper Green River and Uinta Formations. If fracturing is continuous into the lower formations, hydraulic communication is possible.

Groundwater in the regional area varies in boron content, sodium absorption ratio (SAR), and salinity hazard. The available data (Ref. 30) indicate that the following values apply for the immediate vicinity of the tracts.

Location	Sodium Absorption Ratio*	Salinity Hazard* (micromhos/cm)	Boron (mg/l)
10S/21E-16	99 (very high)	3,080 (very high)	–
11S/24E-08	49 (very high)	1,820 (high)	–
11S/21E-31	75 (very high)	1,490 (high)	0.29
11S/24E-06	60 (very high)	1,800 (high)	–

*Based upon irrigation water classification of the U.S. Salinity Laboratory Staff, 1954

These data indicate a poor to marginal supply of water in terms of quality for most uses. In general, the best water quality occurs in the Book Cliffs area far south of the tracts.

Much water quality information has been obtained from wells drilled for this investigation, and a comprehensive list of constituents was determined for each sample. The data available for the Bird's Nest Aquifer are summarized in Figure 2.3-7, which shows Stiff diagrams of groundwater quality. The water is decidedly a sodium, bicarbonate-sulfate water with TDS ranging from about 1,700 to 4,000 mg/l.

2.3.3.9 Groundwater Use

Groundwater use is somewhat restricted by its quality. Shallow alluvial wells supply the southern Uinta Basin with most of the groundwater, which is used mainly for stock watering and other domestic supplies (Ref. 30). The American Gilsonite Company has drilled about 21 wells in the alluvium of the White River near the Ignatio Stage Stop. The wells supply water for the Gilsonite mining operation and for the inhabitants of Bonanza, Utah. A few deep oil and gas wells near the tracts have been converted to stock watering wells.

LEGEND

NOTE: NUMBER AT TOP OF FIGURE IS TOTAL DISSOLVED SOLIDS IN MG/L.

STIFF DIAGRAM SCALE

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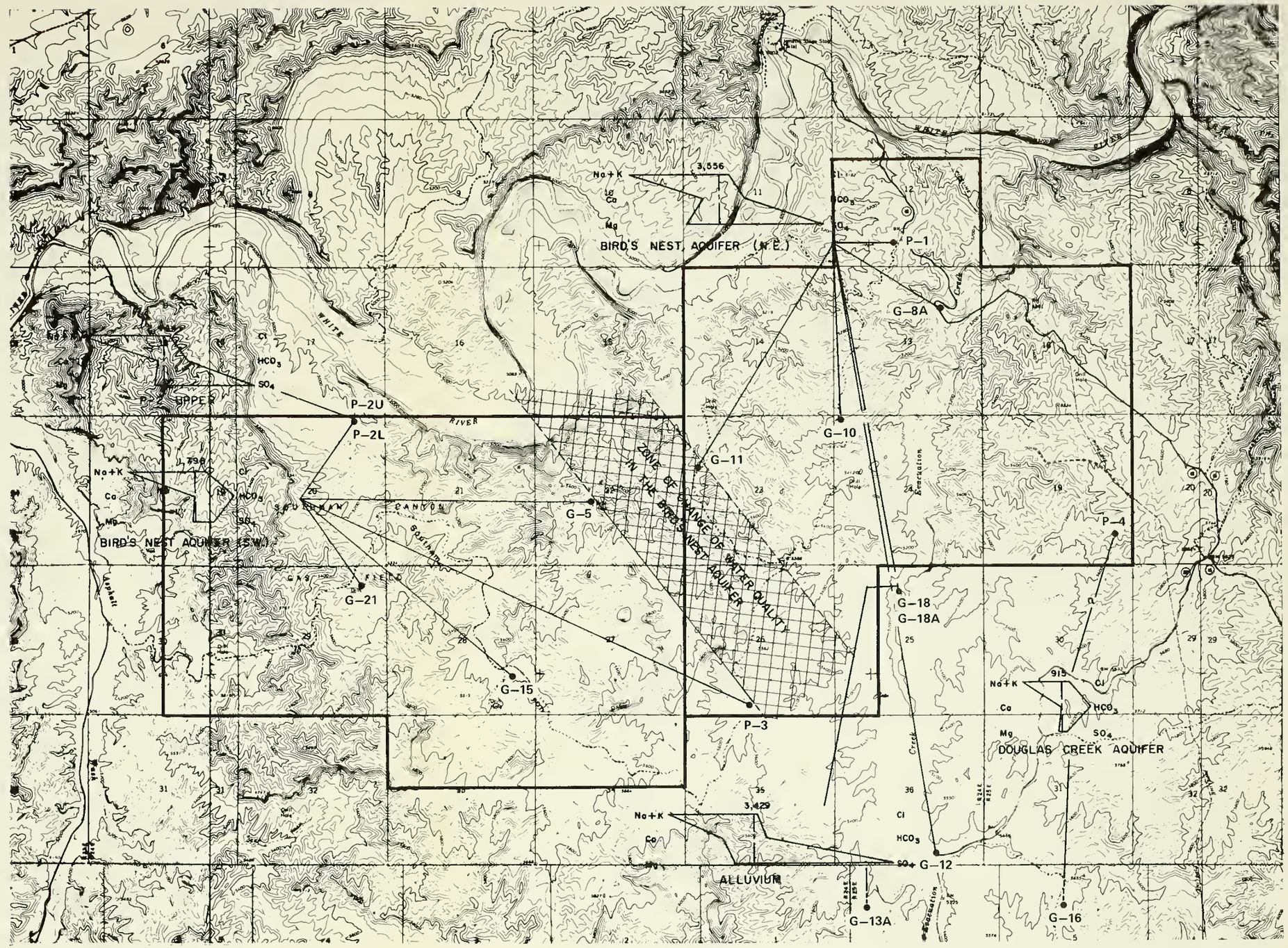
MILLIEQUIVALENTS/LITER



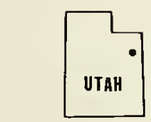


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Figure 2.3-7. Stiff Diagrams of Water Quality, Tracts U-a and U-b

Section 2.4

Section 2.4

AIR RESOURCES

In this section, baseline air quality, meteorology, climatology, radiation, and ambient sound levels are described.

2.4.1 DESCRIPTION CLIMATOLOGY

No long-term climatological data are available for the oil shale tracts or for the region near the tracts. Two types of data are presented in this section: short-term onsite data collected since November 1974 and data amassed at other proximate locations that were used to synthesize a climatological description of the site area.

2.4.1.1 Precipitation and Evaporation

A network of precipitation gauges was established on or near Tracts U-a and U-b. These gauges began operation during the last quarter of 1974, and records were compiled for 1 year. The relationship between precipitation and elevation, as revealed by these data, is shown in Figure 2.4-1. Precipitation averaged 8 to 11 inches on the tracts, increasing by about 3 inches for each 1,000 foot rise in elevation. Evaporation pan records from May through September 1975 showed potential evaporation of 39.2 inches per year in Southam Canyon and 39.4 inches per year on the ridge above Evacuation Creek.

2.4.1.2 Temperature

Table 2.4-1 presents the highest, lowest, and mean temperatures of each month at Bonanza, based on more than 19 years of record. The mean

monthly winter temperature ranged from 26°F to 20°F while the mean monthly summer temperature ranged from 67°F to 75°F. The highest temperature recorded at Bonanza was 105°F in July; the lowest temperature recorded was -31°F in January.

Summer averages were the same from year to year (standard deviations were less than 3.6°F), while the winter-to-winter variability was much greater, with standard deviations sometimes exceeding 7.2°F.

2.4.1.3 Wind

The results of on-tract wind measurements since November 1974 are given in Subsection 2.4.2.1.

2.4.1.4 Mixing Height

Mixing height is the depth of the atmosphere in which there is rapid lateral and vertical mixing below an inversion. Mean mixing heights at Grand Junction, which should be somewhat representative of eastern Utah, are presented in Table 2.4-2. These heights were computed from rawinsonde soundings taken at Grand Junction during the period January 1960 through December 1964.

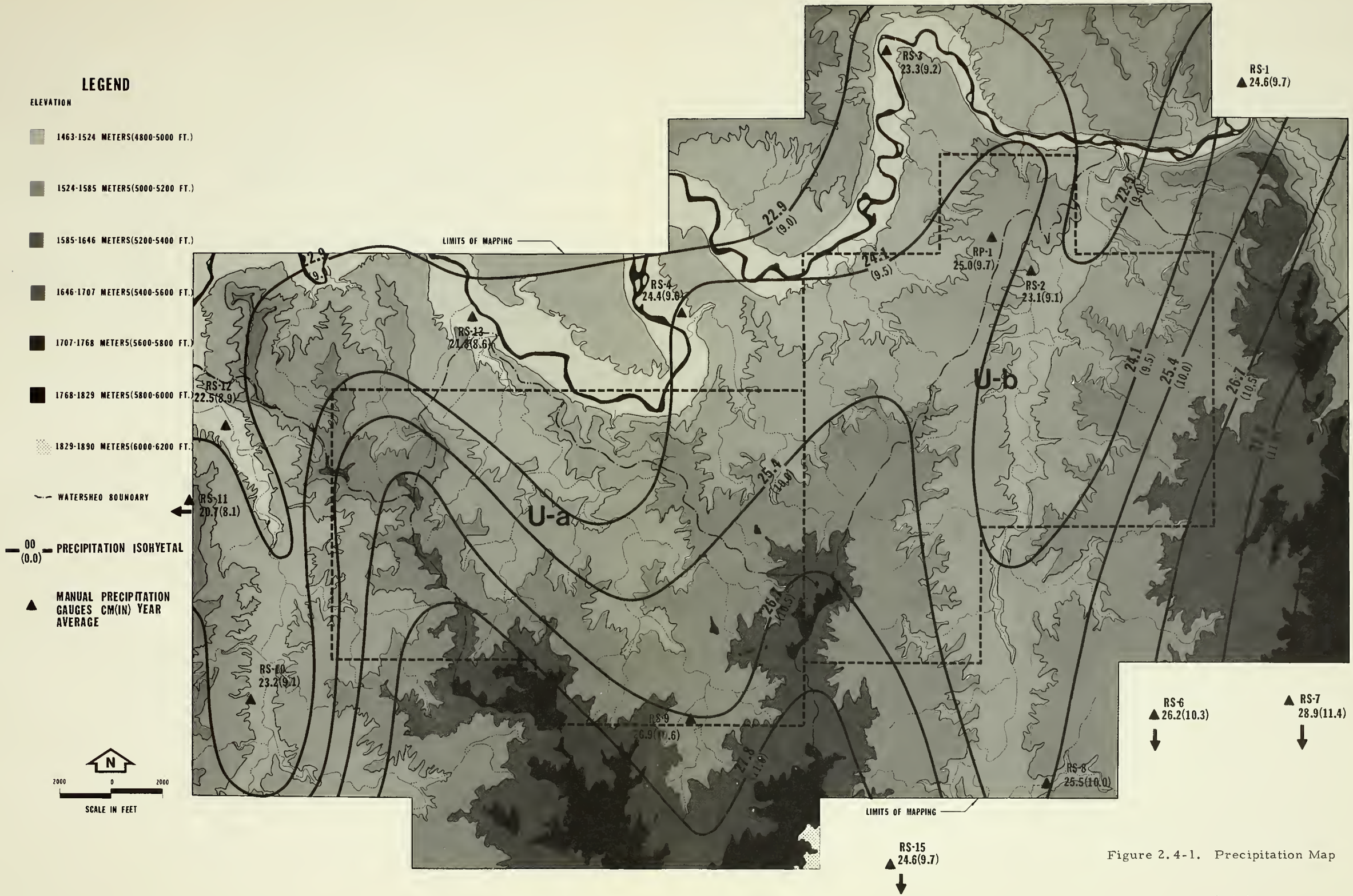


Figure 2.4-1. Precipitation Map

Table 2.4-1

HIGHEST, LOWEST, AND MEAN TEMPERATURES
BY MONTH AT BONANZA

	No. of Years		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean	20	°C	-7	-4	3	10	16	19	24	23	18	11	2	-3
		(°F)	(20)	(25)	(37)	(50)	(60)	(67)	(75)	(73)	(64)	(52)	(36)	(26)
Max.	20	°C	16	17	25	32	34	39	41	38	38	32	25	.16
		(°F)	(61)	(63)	(77)	(90)	(94)	(103)	(105)	(101)	(101)	(89)	(77)	(61)
Min.	19	°C	-32	-29	-21	-15	-4	-3	5	1	-2	-11	-21	-23
		(°F)	(-25)	(-21)	(-5)	(5)	(24)	(27)	(41)	(34)	(29)	(12)	(-5)	(-10)

Table 2.4-2

MEAN MIXING HEIGHTS AT GRAND JUNCTION
FROM HOLZWORTH (1972)

Season	Mixing Height	
	Morning (0500 MST)	Afternoon (1700 MST)
Winter	329 m (1,079 ft)	1,160 m (3,806 ft)
Spring	628 m (2,060 ft)	3,166 m (10,387 ft)
Summer	307 m (1,007 ft)	3,940 m (12,926 ft)
Autumn	273 m (896 ft)	2,133 m (6,998 ft)
Annual	384 m (1,260 ft)	2,600 m (8,530 ft)

2.4.2 METEOROLOGY

2.4.2.1 Surface Meteorology

The surface airflow pattern on the tracts is complicated by terrain effects. During the early morning hours drainage flows dominated; flows were towards low terrain and along the White River. A typical morning airflow pattern on the tracts is presented in Figure 2.4-2. In the afternoon, winds were stronger and more organized. The flow was generally from the west or southwest. Typical afternoon airflow patterns for July and October 1975 are presented in Figures 2.4-3 and 2.4-4, respectively. Anomalies at Sites A4 and A5 can be attributed to vertical motions induced by the very complicated topography surrounding these locations.

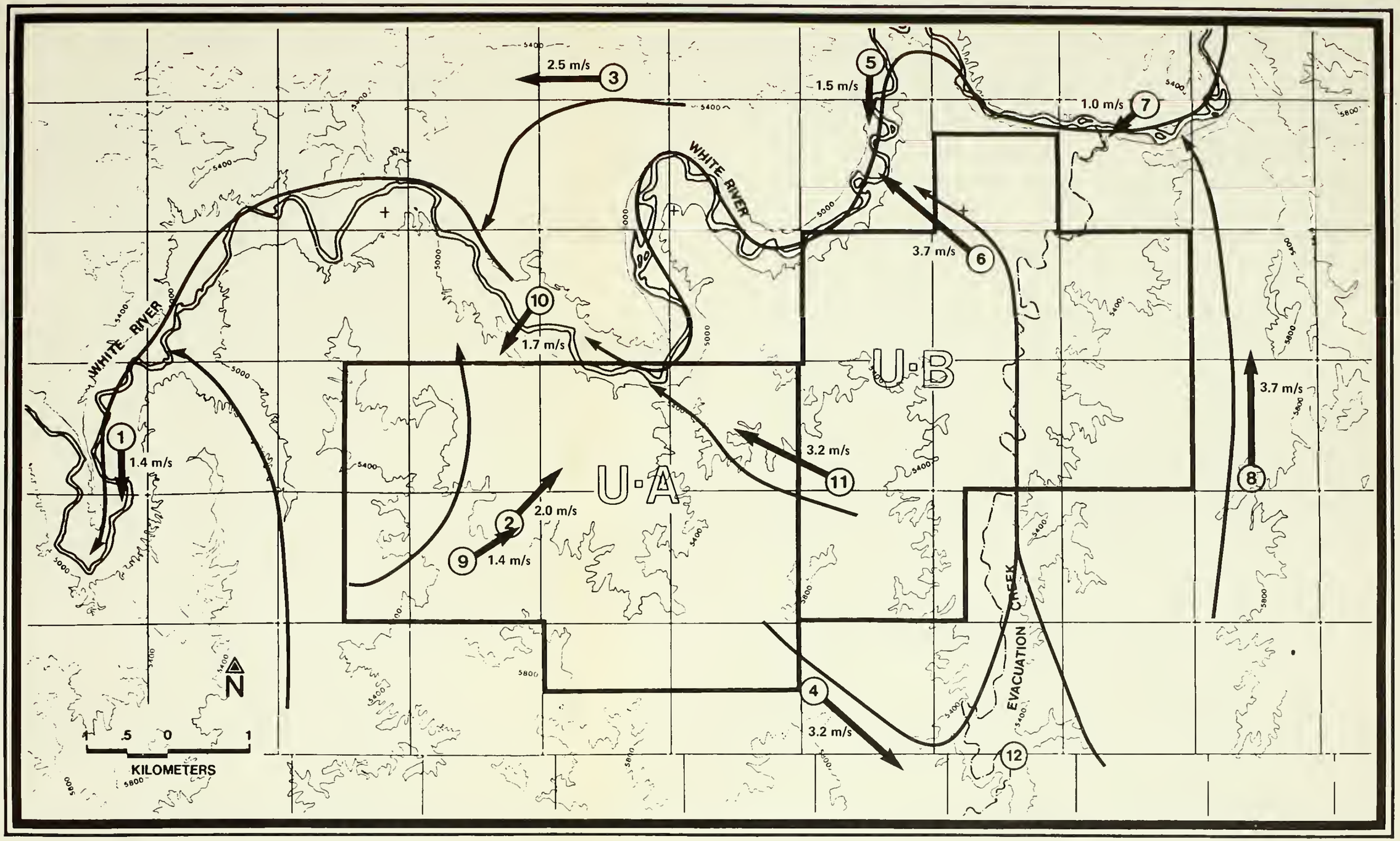
The relative percentage frequency distribution of wind speed at Site A6 in January, April, July, and October 1975 is presented in Table 2.4-3. For more than 78 percent of the time in January, the wind speed was

Table 2.4-3

PERCENTAGE FREQUENCY DISTRIBUTION OF WIND SPEED AT SITE A6 IN JANUARY, APRIL, AND JULY 1975

Wind Speed		Jan	Apr	July	Oct
m/s	mph				
0-1.3	0-3.0	28	14	9	1
1.4-2.6	3.1-6.0	51	23	28	18
2.7-5.3	6.0-12.0	13	32	48	48
5.4-8.0	12.2-18.0	6	16	12	21
8.1-11.1	18.1-25.0	2	13	3	8
11.2-15.6	25.1-35.0	0	2	0	3
>15.6	35.0	0	< 1	0	1

Entries under "Jan," "Apr," "July," and "Oct" indicate the percentage of the time that the wind speeds were within the ranges shown.

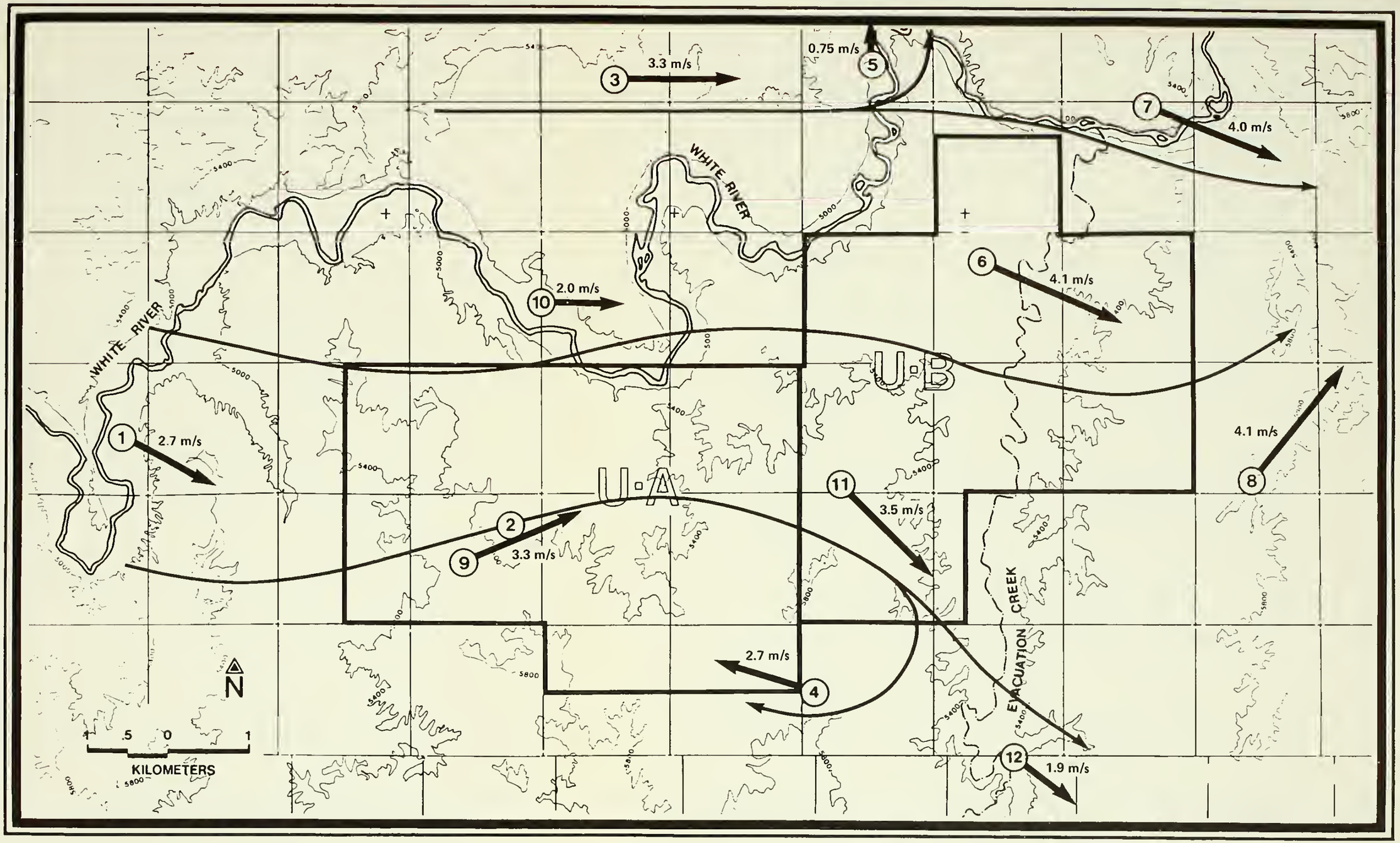


5 m/s — WIND VELOCITY AND DIRECTION AT MONITORING SITE

STREAMLINE

(6) AIR MONITORING STATION

Figure 2.4-2. Typical Morning Airflow Pattern on Tracts U-a and U-b, October 1975



5 m/s — WIND VELOCITY AND DIRECTION AT MONITORING SITE

STREAMLINES

(6) AIR MONITORING STATION

Figure 2.4-3. Typical Afternoon Airflow Pattern on Tracts U-a and U-b, July 1975

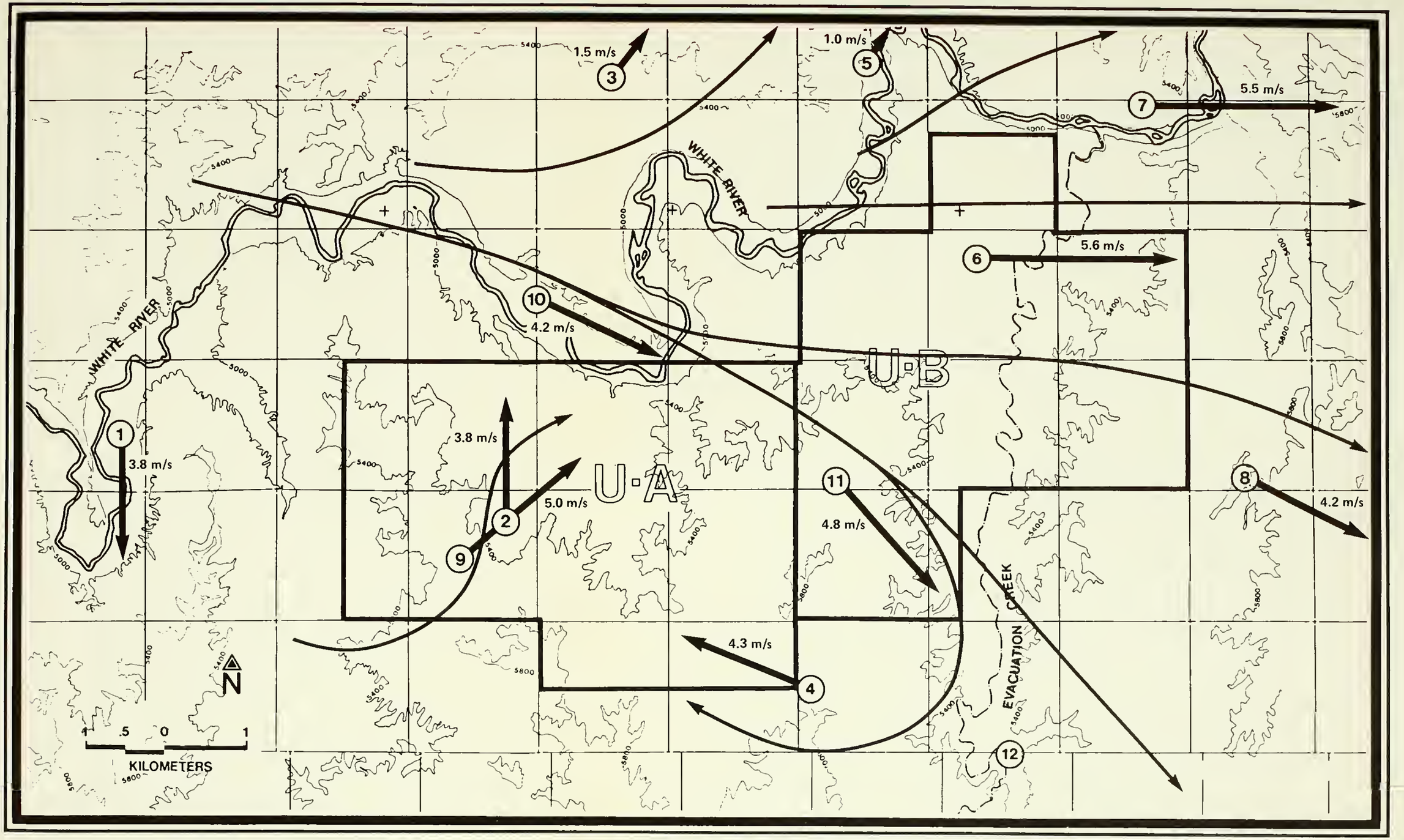


Figure 2.4-4. Typical Afternoon Airflow Pattern on Tracts U-a and U-b, October 1975

less than or equal to 6 miles per hour (mph). This frequency of low wind speeds was down to 37 percent in April, to 38 percent in July, and to 19 percent in October. In January and July, the wind speed exceeded 18 mph less than 3 percent of the time.

During the whole measurement period, low winds were usually observed at night and in the early morning, especially, between 0600 to 0900 MST, while strong winds were generally observed between 1300 to 1700 MST. Wind speeds over the ridges and widely exposed terrain were usually much higher than those in the protected valleys.

The winter quarter had the highest frequency of low winds. Since the dispersion of windborne effluents is strongly correlated to the wind speed, i.e., strong winds enhance dispersion, the winter quarter would probably be the period with the highest air pollution potential.

2.4.2.2 Upper Air Meteorology

Rawinsonde soundings of upper air temperature, relative humidity, and wind over Tract U-b at Site A6 were taken twice daily on every sixth day, with one release in the morning at dawn and one in the early afternoon. Continuous acoustic soundings of the bottom half-mile of the atmosphere were also taken at the same location.

For all of the study period to date, a surface-based inversion attributable to nocturnal cooling of the earth's surface was generally observed in the morning, and usually disappeared in the afternoon. The average thickness of the morning inversion descreased from about 732 feet in February to 308 feet in April, then increased to 1,122 feet in July and to 1,348 feet in October. The strength of the inversion in February, April and October was about $1.1^{\circ}F$ per 100 feet. The strength of the inversion in July was much weaker with an average of $0.5^{\circ}F$ per 100 feet.

Relative humidity in the lower half mile above the ground was about 70 percent in the morning and about 50 percent in the afternoon, with no significant change from February to April. In July, the relative humidity in the lower half-mile decreased to about 50 percent in the morning and to about 30 percent in the afternoon. In October, it was about 40 percent in the morning and about 35 percent in the afternoon.

In the first half mile above the ground, the winds were quite variable from day to day. Above this first half mile, winds were usually from the west, with an average speed of about 17.9 mph during the winter and spring quarters and about 8.9 mph in the summer and fall.

2.4.2.3 Diffusivity

Two characterizations of atmospheric diffusivity have been applied to the meteorology on the tracts. The first, which relies wholly on the inversion characteristics, shows that mixing was always limited in the mornings by surface-based inversions of various strengths and that the tops of these surface inversions varied from 330 to 2,300 feet. Early afternoon mixing heights were generally, but not always, unlimited.

The second approach, which uses equations for the diffusion of a plume, implies that in the afternoon pollutant concentrations caused by a given low-level source are expected to be two to three times lower than in the morning. In the summer, taking July as a representative month, the values at A6 at 0500 and 1400 MST were 0.29 and 0.86 m/s, respectively. In October, average diffusivity values at A2 and A6 in the morning were both around 0.40 m/s. In the afternoon, average diffusivity values at A2 and A6 were 0.59 and 0.87 m/s, respectively.

The calmest conditions and the longest-lived clouds usually occurred in the morning in both winter and summer, and in the evening in winter;

noontime conditions seldom allowed tracking for more than a few minutes, and often were so windy that the balloons could not be launched at all. All the clouds remained at a relatively constant altitude or rose higher as they traveled, with the notable exception of one cloud which descended into Evaluation Creek. This cloud was the only one generated at noon that had a significant lifetime.

2.4.3 AIR QUALITY

2.4.3.1 Gaseous Pollutants

Sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) are monitored at eight sites on the tracts. In addition, carbon monoxide (CO), hydrocarbons (HC), nitrogen dioxide (NO_2) and ozone (O_3) are monitored at three of the eight sites. Table 2.4-4 shows the Federal Ambient Air Quality Standards (AAQS) for the various gaseous pollutants monitored on the tracts. The State Air Quality Regulations incorporate the federal standards.

Air quality on the tracts, relative to federal standards, was consistently very good considering the comparatively few sources of air contamination in the area. During the early months of operation, propane generators were used to supply power to the stations. This caused some abnormal measurements to be developed at several stations. When commercial electricity became available, this situation was soon corrected, and pollutant levels dropped for all air pollutants, except nonmethane hydrocarbons. High nonmethane hydrocarbon (NMHC) readings are frequently observed in unpopulated areas throughout the United States, hence the levels found on the tracts are not uncommon. Table 2.4-5 shows the highest 0600 to 0900 MST nonmethane hydrocarbons reading at Stations A2, A3, and A6 for each of the last four quarters.

Other than NMHC, the only consistently measureable gaseous pollutant was ozone. Values in excess of Federal Air Quality Standards for ozone

Table 2.4-4

FEDERAL AIR QUALITY STANDARDS
FOR GASEOUS POLLUTANTS

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Ozone (O_3)	1 hour	160 $\mu g/m^3$ (0.08 ppm)	Same as Primary
Carbon Monoxide (CO)	8 hours	10 mg/m^3 (9 ppm)	Same as Primary
	1 hour	40 mg/m^3 (35 ppm)	Same as Primary
Sulfur Dioxide (SO_2)	Annual Average	80 $\mu g/m^3$ (0.03 ppm)	
	24 hours	365 $\mu g/m^3$ (0.14 ppm)	
	3 hours	—	1,300 $\mu g/m^3$ (0.5 ppm)
Nitrogen Dioxide (NO_2)	Annual Average	100 $\mu g/m^3$ (0.05 ppm)	Same as Primary
Hydrocarbons (HC) (not containing methane)	3 hours (6-9 a.m.)	160 $\mu g/m^3$ (0.24 ppm)	Same as Primary

Table 2.4-5

PEAK TIME 0600 to 0900 NMHC READINGS ($\mu g/m^3$)
AT STATIONS A2, A3, AND A6

Season	A2	A3	A6
Winter	1,110	630	1,210
Spring	100	(a)	1,400
Summer	480	1,970	390
Fall	630	1,460	280

(a) No data were collected in that quarter due to instrument problem.

were observed in every quarter. The peak hour and average ozone values and the percent of observations exceeding Federal AAQS at each site for each quarter are tabulated in Table 2.4-6.

The measured values of all other gaseous pollutants were very low, often near the detection threshold of the instruments, and all well below any applicable standards. To permit comparison with SO_2 standards, Table 2.4-7 shows peak SO_2 readings for time averages. Table 2.4-8 outlines the highest and average hourly values for the remaining pollutants.

In February and June 1975, when the plume diffusion experiments were being conducted, air pollution and meteorological sensors were flown over in a light plane to determine vertical and horizontal profiles of air pollution in the Uinta Basin. It was found that surface pollutant levels, in terms of ozone and particulates, showed no spatial variability with location, except for a highly localized ozone depletion over Vernal in the early morning hours during very stable winter days. In addition, vertical profiles of ozone displayed no major variation, again with the exception of localized effects over Vernal. Suspended particulate concentrations were slightly higher near the ground and in the mixed layer than above, as would be normal.

Ozone increased during the daylight hours, but there was no significant diurnal effect on particulates. The low uniform values of ozone concentration recorded did not provide any clues to the sources of relatively high ozone values observed in the fall and again in the late spring. Since ozone levels aloft were equal to, or less than, those near the surface (again with the exception of the area near Vernal), the upper atmosphere was not a source during these sampling flights, although stratospheric ozone is a possible source at other times.

Table 2.4-6

PEAK AND AVERAGE HOURLY VALUES OF OZONE ($\mu g/m^3$)

Site	Quarter[(a)]	Peak Values	Average Values	Number of Observations	Percent of Observations Exceeding Standards
A2	Winter	170	70	490	1
	Spring	180	130	462	6
	Summer	220	140	735	27
	Fall	120	70	719	0
A3	Winter	130	85	735	0
	Spring	150	100	277	0
	Summer	130	100	568	1
	Fall	150	100	519	1
A6	Winter	130	70	482	0
	Spring	200	110	716	3
	Summer	150	90	652	0
	Fall	110	60	721	0

(a) Each quarter is characterized by data for the mid-month of that quarter, e.g., spring is represented by April.

Table 2.4-7

PEAK 3-HOUR, 24-HOUR, AND ANNUAL AVERAGES OF SO_2 (g/m^3) AT STATIONS A1 TO A8 FOR EACH OF THE LAST FOUR QUARTERS

Station	Peak 3-Hour Average				Peak 24-Hour Average				Annual Average
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	
A1	N/A	5	10	15	N/A	5	5	10	0
A2	15	25	10	10	10	15	10	5	5
A3	10	10	10	10	10	10	10	10	5
A4	0	5	5	10	0	5	0	0	0
A5	20	35	20	10	15	15	10	5	5
A6	10	10	10	5	5	5	10	5	5
A7	30	25	40	10	20	20	25	5	10
A8	10	10	10	20	5	5	10	5	5

Table 2.4-8

HIGHEST AND AVERAGE HOUR VALUES OF H_2S, CO, AND NO_2

Pollutant	Site	Peak				Average Values			
		Winter[a]	Spring	Summer	Fall	Winter	Spring	Summer	Fall
H_2S[b] ($\mu g/m^3$)	A1	--	--	5	5	--	--	0	0
	A2	60	10	0	0	25	0	0	0
	A3	15	15	5	10	10	10	5	0
	A4	--	15	0	10	--	10	0	0
	A5	5	5	5	0	0	0	0	0
	A6	15	--	30	10	5	--	10	0
	A7	20	--	5	5	15	--	0	0
	A8	5	5	10	5	0	0	0	0
CO[b] (mg/m^3)	A2	3.0	1.0	.5	.5	.5	.1	.1	.2
	A3	--	--	1.4	1.1	--	--	.2	.3
	A6	1.3	0.4	--	1.2	.3	0	--	.3
NO_2[b] ($\mu g/m^3$)	A2	20	60	20	20	10	10	0	0
	A3	10	20	30	10	0	10	0	0
	A6	--	10	55	20	--	0	25	0

(a) Each quarter is characterized by data for the mid-month of that quarter, e.g., spring is represented by April

(b) Nominal detection limit for instrumentation on the tracts is:

H_2S - 7 g/m^3 (0.0005 ppm)
CO - 0.1 mg/m^3 (0.1 ppm)
NO_2 - 10 g/m^3 (0.005 ppm)

Values below the detection limit have no significance.

2.4.3.2 Particulates and Trace Metals

Table 2.4-9 shows the geometric mean, standard geometric deviation, maximum, and minimum of particulate concentrations in $\mu g/m^3$ at all sites in the last four quarters.

None of the recorded values exceeded federal or state standards, shown in Table 2.4-10. The most stringent standard is the national secondary standard that sets the upper limit at 150 $\mu g/m^3$ averaged over 24 hours; this is not to be exceeded more than once a year.

Additional particulate samples were collected at Site A2. Most of the elements detected, with the exception of normal soil constituents, were found at concentrations less than or around 10 $\mu g/m^3$. The elements present in larger quantities were Si, S, K, Ca, Ti, Mn, and Fe; all of which are soil-related trace metals.

2.4.3.3 Visibility

A diurnal variation in scattering coefficient was observed in all seasons except the summer, with the night and early morning hours showing about 15 percent more scattering (lower visibility) than the afternoon and evening hours. This diurnal effect shows that fine-scale particulates (of natural and anthropogenic origin) collect near the ground during the stable, calm night hours, then are mixed into the atmosphere during the better ventilated daytime hours. However, increased human activity and winds on the tract during the day do not stir up enough dust to counteract this stability. None of the days when photographic visibility measurements were made (on a scheduled basis) presented any obstructions to visibility.

Table 2.4-9

QUARTERLY GEOMETRIC MEANS, STANDARD GEOMETRIC DEVIATIONS, MAXIMUM, MINIMUM, AND ANNUAL GEOMETRIC MEANS OF PARTICULARE CONCENTRATIONS ($\mu g/m^3$)

Measurement[a]	Concentration at the Stations							
	A1	A2	A3	A4	A5	A6	A7	A8
Geom. Mean[b]								
Winter[c]	9.1	8.1	9.4	7.8	11.5	(d)	8.2	7.2
Spring	11.5	11.1	12.1	14.0	21.0	17.2	10.5	21.8
Summer	17.4	11.7	15.9	22.6	41.8	39.2	17.4	23.4
Fall	9.5	10.7	11.3	17.2	31.2	17.2	11.1	18.6
Std. Geom. Dev.								
Winter	1.3	1.5	1.3	1.5	1.4	(d)	1.3	1.4
Spring	1.7	1.9	2.1	1.8	1.7	1.9	2.1	1.8
Summer	2.1	2.7	1.6	1.4	1.9	1.4	1.4	1.5
Fall	1.8	2.0	1.8	1.8	2.3	2.1	1.7	2.0
Maximum								
Winter	14.5	26.8	15.6	15.9	19.8	(d)	13.9	12.4
Spring	29.1	41.7	49.9	44.5	49.5	52.0	46.7	48.4
Summer	48.9	41.4	38.3	57.1	91.8	74.7	31.6	36.8
Fall	31.1	29.6	29.2	47.1	127.4	52.8	26.8	49.7
Minimum								
Winter	4.0	3.3	6.5	4.6	5.3	(d)	5.9	5.3
Spring	4.6	3.9	4.3	6.0	8.7	6.9	2.6	8.0
Summer	4.0	2.0	5.8	15.3	6.4	23.2	7.9	12.5
Fall	4.6	3.3	5.2	4.0	8.6	4.9	3.9	7.9
Ann. Geom. Mean	10.8	10.0	10.7	13.0	22.2	15.5	11.3	15.4

(a) The locations of the air stations are shown in Figure 2.4-2.

(b) Because particulate concentrations were found to be lognormally distributed in general, the geometric mean presented can be considered to correspond to the maximum concentration to be expected at a 50 percent frequency.

(c) Value for each quarter is based on data collected during the 3 months of that quarter.

(d) Sampler malfunction; insufficient data for meaningful statistical analysis.

Table 2.4-10

AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE MATTER ($\mu g/m^3$)

Pollutant	Averaging Time	Federal and State Standards	
		Primary	Secondary
Suspended Particulate Matter	Annual Geometric Mean	75	60
	24 hours	260	150

2.4.4 RADIATION

Continuous monitoring of ambient radiation throughout the tracts showed radiation everywhere throughout the study area to be in the normal ambient range. Measurement by pressurized ionization chamber showed exposure rates varying from 8 to 30 $\mu R/hr$. Localized sources in the vicinity of the monitoring sites have indicated values up to about 60 $\mu R/hr$, still well within the background range. The late summer values tended to be slightly greater than those observed earlier.

Particulate matter collected at A2 and A6 was analyzed for radiation, with results of the analyses of these filter samples showing all radioactive isotope activities to be in the background range. Gross alpha and beta scans were in the vicinity of 0.007 and 0.1 pCi/m^3, respectively. Qualitative gamma scans revealed the presence of Ra^{226} and Bi^{214} at less than 0.7 pCi/m^3, with various other isotopes displaying significantly smaller activities. Both the alpha and beta levels decreased significantly during the first year of monitoring, and do not appear to be correlated with the particulate mass concentrations.

An air sample taken in December 1974 showed a Rn^{222} activity of 0.64 pCi/l. According to the EPA National Environmental Research Center in Las Vegas, Nevada, which analyzed this sample, values below 1.0 pCi/l are considered normal background levels.

Analysis of a U-b core hole shale sample by the EPA Laboratories in Las Vegas revealed a uranium concentration of less than 5 ppm, which is considered negligible. This absence of significant radioactive material in the ore is consistent with the normal radiation levels observed in the air.

2.4.5 SOUND LEVELS

Sound level surveys of the study area were performed during April and August 1975. The surveys showed that the background sound level in wind-free conditions at various locations was 25-26 dBA, with air motion or insects as the dominant identifiable sound source. Air stations near the White River indicated 30 dBA with no wind, with water identified as a sound source. Increases in wind obviously cause higher sound levels, with 60 dBA recorded at A4 in an 11 mph wind. No seasonal change in levels has been observed, although insects were readily identifiable as the dominant source both in quiet locations and in August, but not in the colder weather of April.

Section 2.5

Section 2.5

BIOLOGICAL RESOURCES

The plants and animals on the tracts reflect the area's physical, chemical, and biological conditions. The development of the present desert shrub community has been influenced primarily by climate, including the amount and timing of precipitation, soil types, occurrence of permanent water sources (White River, Evacuation Creek), invertebrate, and vertebrate use of the area. This section has two objectives: to describe the general structure and elements of the tracts' ecosystem, and to summarize some of the important functional relationships that exist among these components.

2.5.1 TERRESTRIAL VEGETATION

2.5.1.1 Community Types and Distribution

The plant communities on the tracts are a part of a widespread and diverse vegetative cover extending over the Uinta Basin. Published reports of the region, aerial photographs, and extensive reconnaissance indicate that the vegetation on the tracts can be grouped into four major vegetation types:

- Sagebrush-Greasewood (Type 1)
- Juniper (Type 2)
- Shadscale (Type 3)
- Riparian (Type 4)

The distribution of these four types is shown in Figure 2.5-1. The primary plant species observed in the fall and spring in each of the four

vegetation types (plant communities) are presented in Table 2.5-1. The relative abundance of each species is indicated by the percentage of the total plant coverage determined during the baseline sampling programs. Cover was estimated for most species at the 90 percent level of significance, within 25 percent of the mean. The exceptions were those species that occurred infrequently, or whose cover attribute was variable and difficult to estimate.

Sagebrush-greasewood type as shown in Figure 2.5-2, is found on deeper soils above the riparian type and below the juniper type. It is extensive and is found on both the broad valleys and canyon bottoms of about 25 percent of the tracts.

Juniper type, as shown in Figure 2.5-3, is found at higher elevations, usually above 5,400 feet. This type consists of open, sparse stands of juniper mixed with a few pinyon pines (Pinus edulis) above 6,000 feet and big sagebrush in draws and valleys. The juniper type covers 35 to 40 percent of the tracts, predominantly on the southern half of Tract U-a.

Shadscale type, as shown in Figure 2.5-4, is found on shallow soils of south- and west-facing slopes and along ridgetops where soil depth is less than 18 inches. The most extensive portion is found on Tract U-b on either side of Evacuation Creek. Approximately 29 percent (about 3,000 acres) of the tracts are covered by the shadscale type.

Riparian type, as shown in Figure 2.5-5, is found along stream courses and river bottoms. Only two on-tract areas are classified as riparian: the borders of Evacuation Creek and the flood plain of the White River. The soils of the narrow Evacuation Creek bottom lands are considerably more saline than those of the White River. The riparian type constitutes approximately 2 percent (about 240 acres) of the vegetation on the project area.

LEGEND

1 - SAGEBRUSH - GREASEWOOD

2 - JUNIPER

3 - SHADSCALE

4 - RIPARIAN

UTAH

N

PHOTO MOSAIC; NOT TO SCALE

Figure 2.5-1. Vegetation Map

Table 2.5-1

PLANT SPECIES IN EACH OF THE PLANT COMMUNITIES

SEGEBRUSH-GREASEWOOD-VEGETATION TYPE 1

Species[a]	Common Name	Composition by Percent of Total Plant Coverage
	Fall 1974	
Sarcobatus vermiculatus	Greasewood	22
Salsola kali	Russian Thistle	21
Artemisia tridentata	Big Sagebrush	17
Artemisia nova	Black Sagebrush	9
Grayia spinosa	Spiny Hop Sage	9
Crytogams	Lichens	6
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	5
Oryzopsis hymenoides	Indian Ricegrass	4
Atriplex confertifolia	Shadscale	2
Gutierrezia sarothrae	Snakeweed	2
Tetradymia spinosa	Horsebrush	1
Others[b]		2
	Spring 1975	
Bromus tectorum	Cheatgrass	17
	Borage Family	12
Grayia spinosa	Spiny Hop Sage	9
Chrysothamnus nauseosus	Rubber Rabbitbrush	9
Stipa comata	Needle-and-Thread Grass	7
Tetradymia spinosa	Horsebrush	6
Sarcobatus vermiculatus	Greasewood	6
Artemisia tridentata	Big Sagebrush	5
Oryzopsis hymenoides	Indian Ricegrass	3
Mentzelia albicaulis	Small-flowered Mentzelia	3
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	3
Opuntia spp.	Prickly-pear Cactus	2
Artemisia nova	Black Sagebrush	2
Atriplex confertifolia	Shadscale	2
Sitanion hystrix	Squirreltail Grass	2
Eurotia lanata	Winterfat	2
Cleome lutea	Pursh	1
Hilaria jamesii	Galleta Grass	1
Lithospermum ruderale	Puccoon	1
Sphaeralcea coccinea	Copper Mallow	1
Salsola kali	Russian Thistle	1
Artemisia spinescens	Bud Sagebrush	1
Others[b]		4

Table 2.5-1 (continued)

JUNIPER-VEGETATION TYPE 2

Species[a]	Common Name	Composition By Percent of Total Plant Coverage
Fall 1974		
Juniperus osteosperma	Juniper	81
Artemisia nova	Black Sagebrush	8
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	2
Hilaria jamesii	Galleta Grass	2
Gutierrezia sarothrae	Snakeweed	1
Atriplex confertifolia	Shadscale	1
Oryzopsis hymenoides	Indian Ricegrass	1
Others[b]		4
Spring 1975		
Juniperus osteosperma	Utah Juniper	56
Sarcobatus vermiculatus	Greasewood	7
Chrysothamnus nauseosus	Rubber Rabbitbrush	5
Stipa comata	Needle-and-Thread Grass	4
Hilaria jamesii	Galleta Grass	4
Artemisin tridentata	Big Sagebrush	3
Hedysarum boreale	Sweetvech	3
Hymenoxys scaposa	Hymenoxys	2
Chrysothamnus greeni	Rabbitbrush	2
Artemisia nova	Black Sagebrush	2
Ephedra virdis	Mormon Tea	2
Oryzopsis hymenoides	Indian Ricegrass	2
Phacelia spp.	Phacelia	1
	Borage Family	1
Artriplex confertifolia	Shadscale	1
Leptodactylon watsonii	Leptodactylon	1
Chenopodium album	Goosefoot	1
Others[b]		3

Table 2.5-1 (continued)

SHADSCALE-VEGETATION TYPE 3

Species[a]	Common Name	Composition By Percent of Total Plant Coverage
Fall 1974		
Artemisia tridentata	Big Sagebrush	33
Atriplex confertifolia	Shadscale	32
Artemisia nova	Black Sagebrush	12
Hilaria jamesii	Galleta Grass	4
Sarcobatus vermiculatus	Greasewood	4
Tetradymia spinosa	Horsebrush	3
Salsola kali	Russian Thistle	2
Gutierrezia sarothrae	Snakeweed	2
Crytograms	Rock Brakes	2
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	1
Others[b]		5
Spring 1975		
Bromus tectorum	Cheatgrass	21
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	11
Chrysothamnus greeni	Rabbitbrush	9
Artemisia tridentata	Big Sagebrush	8
Chorispora tenella	Blue Mustard	7
Hilaria jamesii	Galleta Grass	6
Tetradymia spinosa	Horsebrush	6
Sarcobatus vermiculatus	Greasewood	5
Atriplex confertifolia	Shadscale	4
Opuntia spp.	Prickly-pear Cactus	2
Eriogonum effusum	Wild Buckwheat	2
Sporbolus airoides	Alkali Sacaton	2
Stipa comata	Needle-and-Thread Grass	2
Artemisia spinescens	Bud Sagebrush	2
Suaeda torreyana	Sea-blite	2
Sitanion hystrix	Squirreltail Grass	1
Gutierrezia sarothrae	Snakeweed	1
Suaeda spp.	Sea-blite	1
Oenothera caespitosa	White Stemless Evening Primose	1
Eurotia Lanata	Winterfat	1
Halogeton glomeratus	Halogeton	1
Oryzopsis hymenoides	Indian Ricegrass	1
Eriogonum spp.	Wild Buckwheat	1
	Cruciferae family	1
Sphaeralcea coccinea	Scarlet Mallow	1
Others[b]		1

Table 2.5-1 (continued)

RIPARIAN-VEGETATION TYPE 4

Species[a]	Common Name	Composition By Percent of Total Plant Coverage
Fall 1974		
Populus fremontii	Cottonwood	46
Tamarix pentandra	Salt Cedar	17
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	12
Distichlis stricta	Saltgrass	6
Sarcobatus vermiculatus	Greasewood	5
Chrysothamnus nauseosus	Big Rabbitbrush	4
Gutierrezia sarothrae	Snakeweed	2
Artemisia tridentata	Big Sagebrush	2
Saliz exigua	Willow	1
Salsola kali	Russian Thistle	1
Agropyron smithii	Western Wheatgrass	1
Others[b]		3
Spring 1975		
Populus fremontii	Cottonwood	28
Bromus tectorum	Cheatgrass	15
Sarcobatus vermiculatus	Greasewood	12
Salix spp.	Willow	9
Tamarix pentandra	Salt Cedar	5
Chrysothamnus viscidiflorus	Sticky Flower Rabbitbrush	4
Chrysothamnus nauseosus	Rubber Rabbitbrush	3
Kochia spp.	Burning-bush	3
Melilotis officinalis	Sweet-clover	2
Poa pratensis	Kentucky Bluegrass	2
Distichlis spicata	Saltgrass	2
Chrysothamnus greeni	Rabbitbrush	2
Lepidium spp.	Peppergrass; Pepperweed	1
Distichlis stricta	Saltgrass	1
Cleome lutea	Pursh	1
Sporobolus airoides	Alkali Sacaton	1
Atriplex canescens	Fourwing Saltbrush	1
Ambrosia psilostachya	Western Ragweed	1
Agropyron smithii	Western Wheatgrass	1
Iva axillaris	Marsh Elder	1
Others[b]		5

(a) Toxonomy after Harrington (Ref. 31) and Holmgren and Reveal (Ref. 32).
(b) This group includes the annuals and grasses. The abundance is subject to change from year to year depending upon the favorability of weather and degree of disturbance by animals (wildlife and livestock).

Figure 2.5-2. Sagebrush-Greasewood Type of Southam Canyon

Figure 2.5-3. Juniper Vegetation Type at Higher Elevations

Figure 2.5-4. Shadscale Vegetation Near Evacuation Creek

Figure 2.5-5. Riparian Vegetation Type Along the White River

When considered from a regional viewpoint, the sagebrush, greasewood, and shadscale vegetarian types are continuous with the same plant associations extending to the north and west for 30 to 60 miles. Similarly, the juniper vegetation type found on Tracts U-a and U-b (about 4,500 acres) is continuous into the southern and eastern portion of the Uinta Basin for 20 to 30 miles.

2.5.1.2 Productivity

Productivity studies (Table 2.5-2) indicate that the riparian vegetation type is by far the most productive on the tracts. The productivity estimates, however, have limited value in defining the average yearly productivity of each community. The year 1975 was one in which precipitation, though average in overall quantity, fell mostly during the growing season and resulted in unusually prolific plant growth; yet it is the only year for which data on productivity are available. Therefore, productivity can be compared only between vegetation types sampled on tract; thus, no other inferences should be made from such data.

Productivity is seasonally related to precipitation. Growth of annuals and perennials occurs primarily in early spring and continues as long as water is available (sometimes until late in August). Thus, the greatest amount of forage and cover for animal species using this habitat is available primarily in the late spring and early summer.

Table 2.5-2

VEGETATION PRODUCTIVITY
1975

Vegetation Type	Spring 1975 Productivity of Annuals (lb[a]/acre)	Fall 1975 Productivity of Perennials (lb/acre)
Sagebrush-greasewood	455	960
Juniper	80	580
Shadscale	2,000	360
Riparian	5,260	6,490

[a]Air-dried weight

2.5.1.3 Threatened or Endangered Plants

One species of plant, Gilia mevickarae, is listed as threatened in the state of Utah and has been placed on the federal list to be considered for status as threatened or endangered species. A limited number of individuals of this plant have been found to be in the same region as sagebrush-greasewood and juniper vegetation types. None, however, have been found during the first year environmental baseline study.

2.5.2 MICROORGANISMS

Microorganisms are important in the cycling of mineral nutrients in all natural ecosystems. They break down organic material into inorganic chemical forms that become available for intake by plants.

Microbial and biochemical activities in the ecosystem of the tracts resemble the behavior of these activities in similar western arid areas. The activities are strongly moisture-dependent, i.e., season-dependent.

Data indicate that microbiological activity is concentrated in the top layers of soils surveyed. The plate counts for March through August, show that the number of bacteria decreases with increasing depth in the soil profile. Highest bacterial numbers were often found within the top three centimeters, where most of the decompositional activities take place. At the surface, the bacteria count may be four orders of magnitude greater than at the 40 to 50 centimeter profile. At each station, streptomycetes generally followed the same patterns of distribution with depth as bacteria. Highest streptomycete numbers were found in the 0 to 3 centimeter layer, with twofold decrease in other layers of the soil profile.

As in the case with other ecosystems, the nutrient supply to plants, especially nitrogen, strongly depends on microbial activities. The annual detritus and litter fall decomposes rapidly, and little organic matter accumulates in the soil except under the juniper canopies. Biological activities, however, are limited to the spring and fall when the soil is wet. Although elevated temperatures are conducive to higher biological activities, high summer temperatures in this ecosystem cause soils to dry out, thus lowering microbial activity.

2.5.3 TERRESTRIAL INVERTEBRATES

2.5.3.1 Species Inventory

About 1,500 species of insects have been collected during the baseline study. Other arthropods collected include spiders, mites, scorpions, pseudoscorpions, sun spiders, harvestmen, centipedes, and millipeds. Mites are the most diverse of the noninsect orders, but there has been no concerted effort to collect them. Other terrestrial invertebrates (except for microscopic forms) are few in number and low in diversity.

Apparently all hymenoptera (bees, wasps, and ants) account for at least one-third of all insect species on the tracts; Diptera (flies, gnats, etc.) account for two-sevenths of all species; Coleoptera (beetles) account for about one-sixth; and Hemiptera (bugs, leafhoppers, etc.) account for one-eighth. The rest come to less than one-twentieth of the total. These proportions are somewhat biased by the collecting methods used. More collecting and trapping at night would greatly increase the numbers of nocturnal lepidoptera (moths) and would probably reveal them to be almost as diverse as Hemiptera.

Because they are a basic link in the food chain, terrestrial invertebrates are an important component of the desert ecosystem. Many of the smaller terrestrial vertebrates prey on the numerous invertebrates. In addition, the terrestrial invertebrates assist in the breakdown of plant litter, dead or dying plant roots, and decomposition of animal tissue, thereby converting organic wastes to available plant nutrients.

2.5.3.2 Arthropods of Nuisance or Public Health Significance

Some insects in the area are significant pests to man and domestic animals or are potential public health hazards. Among the Diptera, a mosquito (Aedes nigromaculis), a biting midge (Leptoconops furens), and a deer fly (Sylvius quadrivittatus) are the principal biting species. All are extremely annoying when present in large numbers in the riparian areas, and L. furens is also troublesome in the more upland areas. Several other biting Diptera, such as the biting midges (Culicoides), other mosquitoes, horseflies or deerflies (Tabanidae), and the stable fly (Stomoxys calcitrans), probably exist in the area and may become pests.

Ticks have not been collected, although they undoubtedly are found on the resident deer.

The black widow spider and a species of scorpion are also present. The scorpion is harmless, and the bite of the black widow, although painful and able to cause cramps, is usually not fatal.

Filth-carrying flies, such as houseflies and blow flies, although present, are not abundant. The most common is Phormna regina, a blow fly that commonly breeds in carcasses of deer and large livestock. As human habitation increases, it is inevitable that unless good sanitation precautious are taken, populations of these pests will increase.

2.5.3.3 Protected Arthropod Species

Several species of swallowtail butterflies (Papilis) are being considered for addition to the national rare and endangered species list. None of these has been found on the site to date, but may be expected to reside in the area.

2.5.4 TERRESTRIAL VERTEBRATES

There are two major groups of vertebrates in the project area: one consists of true desert fauna adapted to an arid environment, and the other consists of fauna that require access to surface water. Distinct distributional patterns for each group are evident.

Climate affects vertebrate distribution and density on the tracts. Deer, for example, move from one elevation and exposure to another in winter to avoid extremes in temperature; other migrants appear on site only during favorable seasons; still others burrow; and a few may hibernate to avoid extremes of climate. In general, aboveground vertebrate density on the tracts, as well as species composition, varies with the season. The species composition for each season in the four community types on the tracts is summarized in Table 2.5-3.

Table 2.5-3

NUMBER OF VERTEBRATE SPECIES OBSERVED IN EACH VEGETATION TYPE

Vertebrate Class	Dec. 1974 Vegetation Association				Total No. of Different Species	Feb. 1975 Vegetation Association				Total No. of Different Species
	SG	J	S	R		SG	J	S	R	
Mammals	4	4	7	8	13	5	6	4	3	9
Birds	8	10	5	11	19	11	7	4	11	21
Reptiles	-	-	-	-	-	-	-	-	-	-
Amphibians	-	-	-	-	-	-	-	-	-	-

Vertebrate Class	Apr. 1975[a] Vegetation Association				Total No. of Different Species	June 1975[a] Vegetation Association				Total No. of Different Species
	SG	J	S	R		SG	J	S	R	
Mammals	11	12	8	9	18	12	11	12	12[b]	20[b]
Birds	23	21	27	47[b]	66[b]	49[b]	37[b]	32[b]	73[b]	84[b]
Reptiles	-	1	3	3	4	7[b]	7	5	8	11
Amphibians	-	-	-	-		-	-	-	2[b]	2[b]

Vertebrate Class	Aug. 1975[a] Vegetation Association				Total No. of Different Species	Oct. 1975[a] Vegetation Association				Total No. of Different Species
	SG	J	S	R		SG	J	S	R	
Mammals	15[b]	12[b]	12[b]	10[b]	19[b]	9	11[b]	5	10	16[b]
Birds	30	19[b]	22[b]	44[b]	58[b]	21	20	16	27	43[b]
Reptiles	8	7	7	9	11	4	7	4	4	10
Amphibians	--	--	--	2	2	--	--	--	--	--

Vertebrate Class	Maximum Total No. of Different Species,[c] All Seasons
Mammals	29
Birds	114
Reptiles	11
Amphibians	4

(a) Reptiles and amphibians sampled only in April, June, and August 1975
(b) Some species identifications unconformed on tract
(c) The reader interested in a detailed compilation of the species is directed to the FYEBR Biological Resources section
SG - Sagebrush-greasewood
J - Juniper
S - Shadscale
R - Riparian

2.5.4.1 Game Species

Big Game. Mule deer are the only big game species identified on the tracts. Some information on on-tract density and seasonal distribution has been acquired during the baseline study program. In February 1975, 20 deer were counted during a helicopter overflight. Three were observed on the White River and 17 in breaks above Hells Hole Canyon. From February to April, deer were scattered throughout the tracts. When the last sheep herd moved off the tracts on April 22, deer began appearing more frequently and showed a strong tendency to concentrate in the riparian type. By May, 50 to 75 deer were on the tracts.

Six deer were fitted with radio transmitting collars. Subsequent monitoring indicated little net movement: deer were moving into side canyons and returning to the river after 2 to 3 days. During the spring and summer, the upland areas provide a wide variety of browse, ranging from serviceberry, rabbitbrush, and bitterbrush to understory grasses and herbs. The heavy dependence on the riparian area is due to the extensive cover and the availability of water and food in this vegetation type. Succulent food availability is especially important for the production of milk in does nursing fawns. In September, deer were again moving back and forth to the river, but for longer time periods. In the winter, they are forced to rely on less desirable browse such as sagebrush.

From September to November, a fall productivity count of the tracts and the 1-mile perimeter yielded 64 does, 52 fawns, and 3 bucks, for a fawn-to-doe ratio of 81 percent. The remainder of Big Game Management Unit 28A (Utah Division of Wildlife Resources) exhibited a 72 percent fawn-to-doe ratio.

The Utah Division of Wildlife Resources verified that 10 deer were harvested from the tracts during the 1975 Utah deer hunt. Hunter success on opening weekend was slightly higher on the tracts (15.6 percent versus 13.5 percent) than on the rest of Unit 28A.

A December trend count yielded 152 deer observed on the tracts and the 1-mile perimeter around the tracts (26,018 acres), for an arithmetic average density of 3.7 deer per square mile. Because the amount of usable habitat may be only about one-half the total area on the tracts, the actual average density may be nearly twice as high. As shown in Figure 2.5-6, the deer left the river and moved into five main upland areas with the onset of winter temperature inversions on the White River.

During the year, no on-tract sightings were made of elk or antelope, two other regional big game species. Two sightings of antelope were made, however, in areas about 1-1/4 miles north of the White River.

Small Game. Mountain lions are classified as small game in Utah. They seem to be only casual visitors on the tracts: just two sightings were made near the tracts in 1975. The only mammalian small game species observed on the tracts during the baseline study was the cottontail rabbit. Cottontail rabbits are common in all drainages, particularly in the relatively moist sagebrush-greasewood vegetation type. During the winter and spring, they are the only native diurnal mammal regularly seen in all vegetation types. Desert cottontails appeared to increase markedly in numbers during the late summer and fall, with estimated densities ranging up to 0.6 per acre in June, 0.7 per acre in August, and 1.3 per acre in October.

Game birds observed on or near the tracts include mourning doves, common snipe, Canada geese, and six species of ducks. The lease areas support a substantial breeding population of mourning doves, and a small breeding population of Canada geese along the White River (about 2.4 birds per mile of river traveled from Hells Hole Canyon to Asphalt Wash in July). Three pairs of geese produced 18 offspring in 1975, and by September, all the geese had left the tracts. The 1975 population data for geese in the study area are summarized in Table 2.5-4.

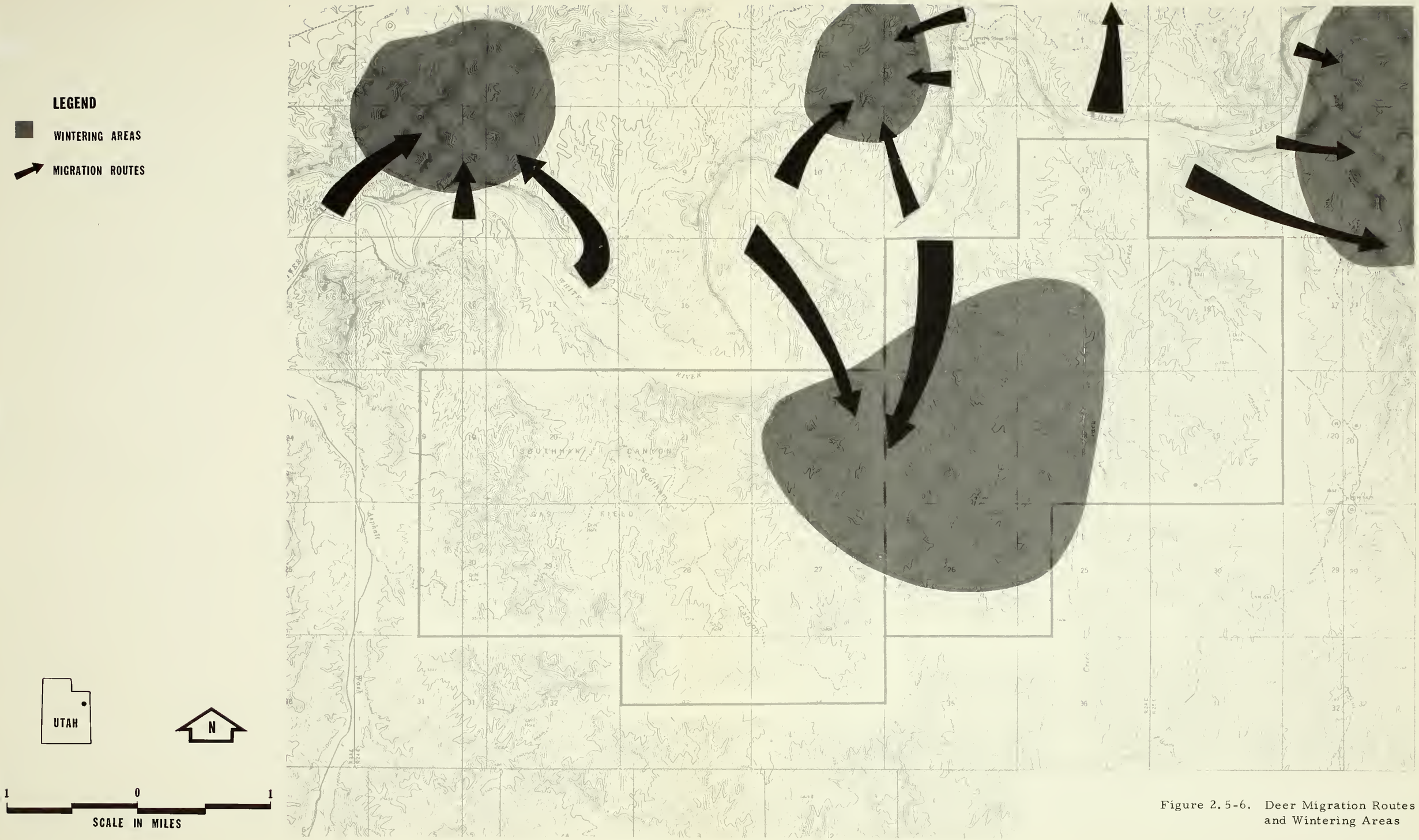


Figure 2.5-6. Deer Migration Routes and Wintering Areas

Table 2.5-4

1975 CANADA GOOSE POPULATION DATA

	Pairs	Unpaired	Juve-nile	Mixed Young and Old	Unclas-sified Birds	Total Birds
March 18	11	2	—	—	—	24
April 11	11	6	—	—	—	28
July	3	1	18	8	10	43
September	0	0	0	0	0	0

2.5.4.2 Livestock

Between December 16 and April 30 in the 1974-1975 season, a total of 6,950 sheep grazed on the three allotments on the tracts as shown in Figure 2.5-7. In addition, some 14,000 sheep are driven through the lease area twice each year, along the main county road and Southam Canyon Road. At present, a total of approximately 4,220 animal units per month (AUM) are being permitted on the three grazing allotments that encompass the tracts. During 1974-1975, an average of approximately 0.1 AUM per acre was utilized and distributed in the three allotments in the following manner, Hell's Hole 0.18, Southam 0.07 and Wagon Hound 0.08. Additional inactive permits allot 1,675 AUM's for 5,500 sheep. Furthermore, approximately 160 cattle graze from June 1 to October 31 of each year along the river bottom and occasionally move into the nearby sagebrush-grass slopes.

2.5.4.3 Nongame Mammals

Twenty-five species of mammals other than domestic livestock have been identified on or within 1 mile of the tracts. The results of the baseline study show that species number varies little from one vegetation type to

another, with 15 verified species seen in sagebrush-greasewood, 14 in juniper, 14 in shadscale, and 16 in riparian.

Estimated densities of diurnal native mammals were highest in sagebrush-greasewood and riparian vegetation types and were lowest in shadscale. Densities tended to increase during the spring and summer reproductive season and decrease at other times.

During the summer and fall, estimated numbers per acre of diurnal mammals were generally highest on the sagebrush-greasewood and riparian sampling sites (up to about 1.5 in sagebrush-greasewood and 1.3 in riparian) and lowest on the shadscale sites (up to about 0.7).

The presence of sheep or cattle on a baseline study transect tended to reduce the numbers of native mammals seen. The only nongame native diurnal mammals observed regularly during the summer were whitetail antelope squirrels in sagebrush-greasewood (up to about 0.7 per acre in June) and bats in sagebrush-greasewood and riparian areas.

Four coyote pups were captured on the tracts, and only two others were observed during the 1975 baseline study. Signs of coyotes were found in Southam Canyon and Asphalt Wash, but no dens were located. The low population may have been largely the result of coyote control programs. A professional trapper destroyed seven dens in 1974 and trapped a minimum of 50 coyotes in the project area. Approximately seven coyotes were shot in 1974 under a contract from the U.S. Fish and Wildlife Service.

The bobcat population was also extremely low in 1975; only two bobcats were observed on the tracts.

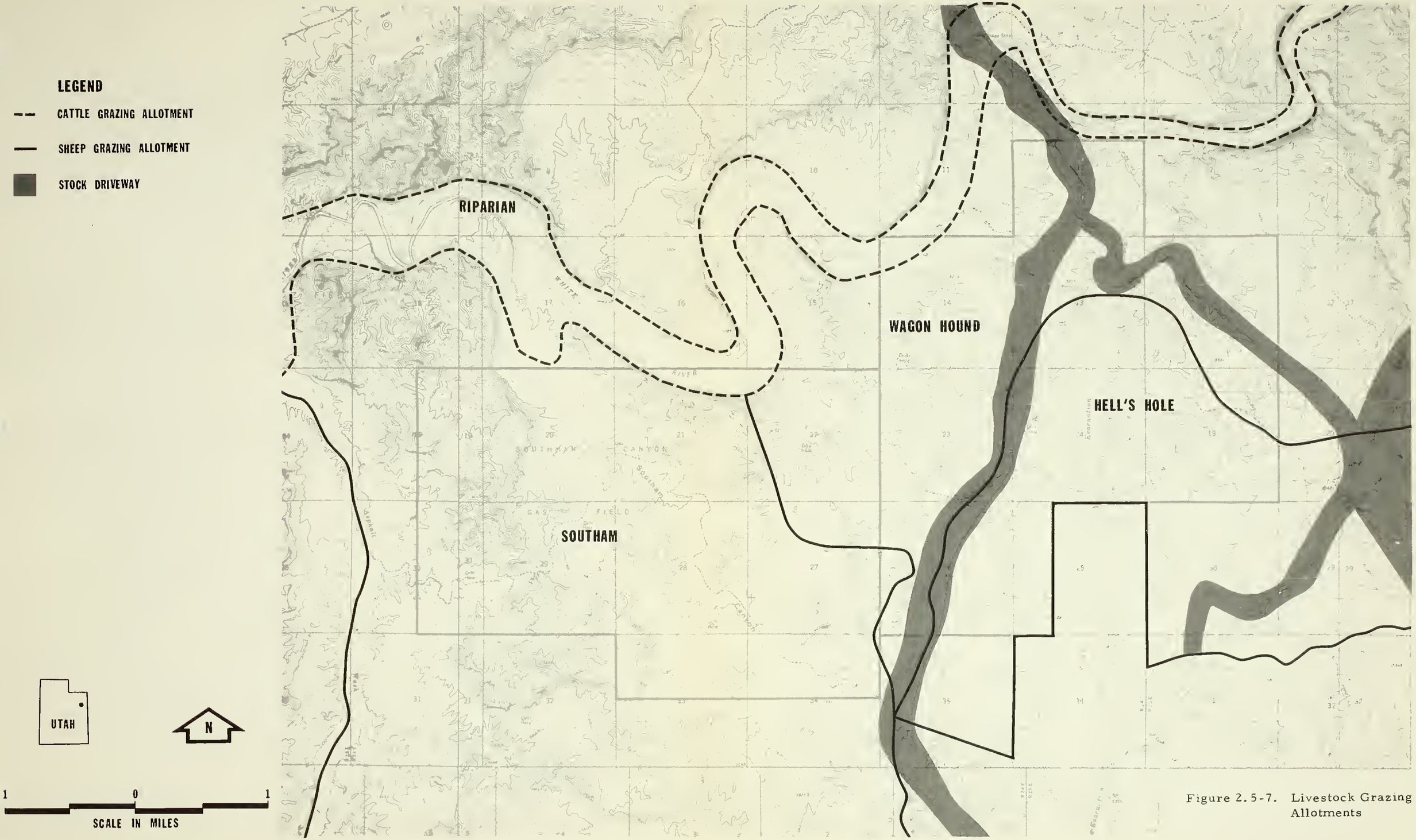


Figure 2.5-7. Livestock Grazing Allotments

Beavers are a common inhabitant of the White River in the area of the tracts. In many sections of the riparian area, beavers have extensively pruned young cottonwood trees, their major food source. In some areas, the pruning has been so extensive that the growth of cottonwoods has been arrested at the sapling stage.

Rodent densities, determined by live-trapping grids in the four major vegetation types, were highest in sagebrush-greasewood (about 25.2 rodents per acre), followed by shadscale (17.1), juniper (11.5), and riparian (0.6). The greasewood vegetation type may support the highest rodent densities because of its higher seed density. Five of the 11 mammalian species captured on the grids had estimated densities of four or more per acre on one or more sampling sites: the deer mouse in greasewood (9.5), juniper (5.0), and shadscale (7.4); the Apache pocket mouse in greasewood (8.6); the Ord kangaroo rat in greasewood (6.5); the desert woodrat in juniper (6.1); and the whitetail antelope squirrel in shadscale (9.0).

Since no species known to exhibit irruptive population dynamics have been identified on the tracts, the population densities of the local rodents may be relatively stable from year to year. Estimated densities of nocturnal rodents were several times higher on the tracts than in some other arid areas of Utah. Sagebrush and shadscale-sagebrush communities in Curlew Valley, Utah-Idaho, which were being intensively studied as part of the Desert Biome Program, were estimated to contain about 4 and 10 animals per acre, respectively (Ref. 33).

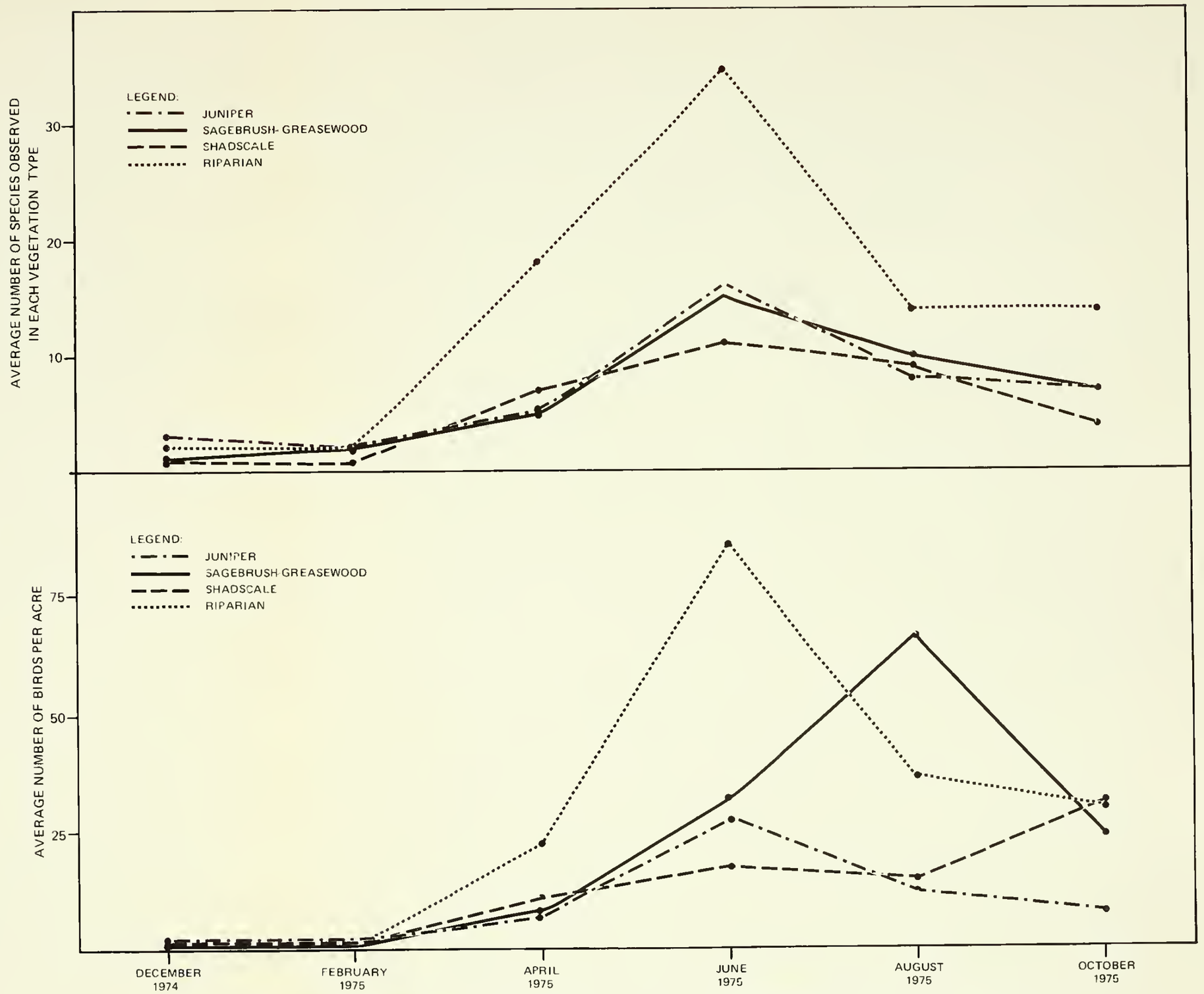
No rare or endangered mammalian species were recorded on or near the tracts.

2.5.4.4 Nongame Birds

A total of 106 species of birds were identified on or within 1 mile of the tracts. Uncertain identification was made of eight additional species, giving a possible total of 114 species. Four times as many species were recorded in June as in December. Of the four major vegetation types, riparian contained the largest number of species (a total of 93 verified species), followed by sagebrush-greasewood (58), juniper (49), and shadscale (38). When the average number of species in each vegetation type is determined, a similar trend in species numbers may be seen, as shown in Figure 2.5-8. Although some species, such as dark-eyed juncos and black and gray-crowned rosy finches, were present on the tracts during the winter and migrated out of the area to breed, the great majority of migratory species were summer residents that vacated the area in the fall.

Riparian areas thus support birds with widely differing habitat requirements, e.g., Canada geese and spotted sandpipers along shorelines, yellow warblers in willow thickets, black-headed grosbeaks and northern orioles in cottonwood stands, rock wrens in cliffs adjacent to riparian vegetation, and Brewer's sparrows in riparian greasewood habitat. In addition, some species, such as mourning doves, visited riparian areas regularly to obtain water. The shadscale vegetation type represents an opposite extreme in that it contains relatively large, unbroken areas of desert scrub habitat and supports a rather small number of species. The sagebrush-greasewood and juniper vegetation types, which interdigitate in many places, represent an intermediate environmental situation.

The density of birds was low in all vegetation types during December and February and increased markedly from February to June. These increases were greatest in the riparian vegetation type, which had an



Note: DATA PRESENTED HAVE BEEN DEVELOPED FROM THE ANNUAL SUMMARY OF BIRD DENSITIES DETERMINED USING FLUSHING TRANSECTS.

Figure 2.5-8. General Trends in Bird Species Variety and Density

average maximum bird density of approximately 80 per acre, as shown in Figure 2.5-8. The most abundant bird species on the sampling sites in December and February were pinyon jays in juniper (with estimated densities of up to 0.9 per acre) and dark-eyed juncos on the riparian site (0.8 per acre). In April, these two species, as well as sage sparrows in shadscale (up to 1.7 per acre) were the most commonly seen species. In June, 14 species had estimated densities of one or more birds per acre on one or more sampling sites. The most abundantly represented species were pinyon jays in sagebrush-greasewood and juniper (up to 3.0 per acre), Brewer's sparrows in sagebrush-greasewood and shadscale (up to 1.8 per acre), and yellow warblers and cliff swallows in the riparian (up to 1.7 per acre and 9.3 per acre, respectively).

Estimated summer densities of birds on the tracts were about twice those reported for the Desert Biome Program's validation sites in Curlew Valley, Utah-Idaho (Ref. 33). In June 1972, for example, Curlew Valley bird density estimates for sagebrush and for shadscale-sagebrush communities were 15 percent of those for the sagebrush-greasewood and 31 percent of those for the shadscale sampling sites, respectively, on the tracts.

2.5.4.5 Raptors

Thirteen raptor species inhabit the area on and around the tracts. During the spring of 1975, the long-eared owl, the goshawk, the Cooper's hawk, the American kestrel, the prairie falcon, the red-tailed hawk, the golden eagle, and the turkey vulture were identified.

Five of these species are known to nest in the area. During a nesting survey in May 1975, five nests were located within a 1-mile perimeter around the tracts. These locations are summarized in Table 2.5-5. No attempt was made to specifically locate nests of the American kestrel, the smallest of the region's raptors.

Table 2.5-5

NESTS IN A 1-MILE PERIMETER AROUND THE TRACTS

Species	No. of Young	Location
Red-tailed hawk	2	Gas well, center fork of Asphalt Wash, Sec. 8 (cliff)
Red-tailed hawk	2	1/4 mile upriver from Ignacio (tree)
Golden eagle	1	Cliffs across river from A-1 (west of U-a)
Prairie falcon	3	Cliffs at A-11 (southwest U-b)
Long-eared owl	3	Mouth of Cowboy Canyon (tree)

During the winter, five species were found on the tracts, including the golden and bald eagle (both mature and immature), the marsh hawk, the prairie falcon, and the rough-legged hawk.

One peregrine falcon, an endangered raptor species, was sighted at the mouth of Wagon Hound Canyon on April 23 and 28. Two other unconfirmed sightings of peregrine falcons were made in December and August. Other raptors sighted during 1975 include the short-eared owl, great-horned owl, and sharp-shinned hawk.

2.5.4.6 Amphibians

Three amphibian species, and possibly a fourth, have been observed along the White River. All are active from April to October.

The leopard frog (Rana pipiens) is the most widespread of the amphibians found. Several thousand tadpoles of this species were observed in a pond adjacent to the White River in June 1975; most of them metamorphosed by July. Several thousand tadpoles of the Great Basin spadefoot toad (Scaphiopus intermontanus) were observed in the same pond. The

rocky mountain toad (Bufo woodhousei) is found infrequently along the White River: only four individuals have been observed. One questionable observation of a western chorus frog (Pseudacris triseriata) was made.

Because of their relative scarcity, the amphibians do not appear to have a significant function in the ecology of the tracts.

2.5.4.7 Reptiles

Six species of lizards and five species of snakes have been observed on the tracts. These species are listed in Table 2.5-6.

The number of species observed was greatest during the summer (June through August). Fewer species were noted in the spring and fall (April and October), and, because of hibernation, none were found aboveground during the winter. Total aboveground densities of reptiles were greatest in the shadscale, about equal for riparian and juniper vegetation types, and least in the sagebrush-greasewood. Snakes accounted for only a small proportion of the total observations of reptiles; they were observed more frequently in the sagebrush-greasewood and riparian habitats.

2.5.5 AQUATIC SYSTEMS

Although aquatic ecosystems within deserts occupy a much smaller part of the area than in other types of communities, their importance appears to be disproportionately large. Water in the desert, whether it be a temporary pool, an intermittent stream, or a river, is the site of intense biological activity. Desert aquatic areas strongly influence adjacent terrestrial areas: many terrestrial invertebrates and vertebrates need regular access to surface water, and, consequently, their behavior patterns are governed by its availability. Desert surface water and groundwater sources are also often focal points of human activity.

Physical and chemical conditions in the White River and Evacuation Creek fluctuate through wide ranges. Since the White River is supported by a large watershed, it fluctuates rather predictably; Evacuation Creek on the other hand, since it is supported by a small watershed, responds to local storms unpredictably. Biological conditions in the White River apparently are regulated by turbidity, changes in water level, and temperature, whereas intermittent flow and alkalinity limit productivity in Evacuation Creek. The limited data indicate that chlorophyll production is low in the White River and low to moderate in Evacuation Creek, indicating low primary productivity.

Aquatic macrophytes are virtually absent from the study area. Aquatic vegetation is probably limited by fluctuating water level and turbidity.

Periphyton productivity fluctuates in accord with seasonally changing conditions. Because phytoplankton is derived almost exclusively from periphyton, it provides further information on periphyton productivity. Seasonal fluctuations in phytoplankton concentrations follow periphyton abundance in a general manner. Plankton cell counts from the White River fluctuate seasonally from about 7,400 to 78,500 cells per liter. Productivity is low during most of the year, but becomes high when snow runoff recedes in July or August.

The White River invertebrate populations are of moderate density and diversity. Density measured quarterly by surber samples has averaged 46.4 organisms per square foot, and densities measured in September averaged 144.7 organisms per square foot. Macroinvertebrate populations increase in autumn when maturation of several mayfly genera reaches levels characteristic of productive streams. Mayflies are the most important group during summer and autumn, but stone flies become important during winter and spring. The dominance of detritus-feeding invertebrates rather than autotrophs suggests that the primary energy input to the river system may be from terrestrial runoff rather than in-stream photosynthesis.

Table 2.5-6

REPTILES OBSERVED ON THE TRACTS

Reptile (Order/Species)	Date/Vegetation Type															
	April 1975				June 1975				August 1975				October 1975			
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
Squamata																
Eastern fence lizard	–	–	x	x	x	x	x	x	x	x	x	x	–	x	–	x
Great basin sagebrush lizard	–	–	x	x	x	x	x	x	x	x	x	x	x	x	x	–
Short-horned lizard	–	–	–	–	–	–	x	–	–	–	x	–	–	–	x	–
Tree lizard	–	–	–	–	–	–	–	x	x	x	–	x	–	x	–	–
Northern side-blotched lizard	–	x	–	–	x	x	–	–	x	x	x	x	x	x	x	x
Western whiptail	–	–	x	x	x	x	–	x	x	x	x	x	–	x	–	–
Western yellow-bellied racer	–	–	–	–	–	–	–	x	–	–	–	x	–	–	–	–
Desert striped whipsnake	–	–	–	–	x	–	x	x	x	x	–	x	–	x	x	–
Great basin gopher snake	–	–	–	–	x	x	x	x	x	–	x	x	x	x	–	x
Wandering garter snake	–	–	–	–	–	–	–	x	–	–	–	x	–	–	–	x
Midget faded rattlesnake	–	–	–	–	x	x	–	–	x	x	x	–	x	–	–	–

G = Sagebrush-Greasewood, J = Juniper, S = Shadscale, R = Riparian

Population densities for local fishes have not been established. The species present near the tracts are typical of streams of this type and region and include flannel-mouth sucker, red shiner, fathead minnow, speckled dace, and roundtail chub. Other species taken from the White River drainage include the carp, bluehead sucker, channel catfish, black bullhead , and smallmouth bass.

Two species of fish native to the White River Basin have been given either threatened or endangered status by the U.S. Fish and Wildlife Service. The Colorado River squawfish, Ptychocheilus lucius, and the humpback chub, Gila cypha, are listed as endangered (Ref. 34). The U.S. Fish and Wildlife Service is considering adding the bonytailed chub, Gila elegans, and the humpback sucker, Xyrauchen texanus, to the threatened or endangered species list. None of these species has been found in the waters on or near the tracts during the baseline study.

2.5.6 ECOLOGICAL INTERRELATIONSHIPS

Natural ecosystems such as those of the tracts comprise a variety of abiotic and biotic components. The abiotic elements include the substrate and meteorological factors, and the biotic elements include plants, animals, and microorganisms. All of these components interact dynamically to produce a functionally integrated ecosystem. In this subsection the structure and operation of the ecosystem on the tracts are described, and some of the more interesting and important interrelationships among components are discussed.

2.5.6.1 General Characteristics of Desert Ecosystems

The tracts are part of the Great Basin desert, the largest desert in North America. Biologists characterize deserts (arid lands) as areas of low annual precipitation, high incident radiation, relatively low soil carbon and nitrogen levels, and high meteorological variability. Much

of the biological activity in deserts is hidden from view because most of the plant and animal biomass is underground and many animals are nocturnal. Some inconspicuous activities and processes, such as detritus food chains and biogeochemical cycles, are of particular importance in deserts.

There are misconceptions about the structure and function of desert ecosystems that are only now being dispelled by research. Deserts have been thought of as relatively simple ecosystems; it is now well known that a desert's response to disturbance is difficult to predict because of the fluctuating meteorological conditions and the plasticity of desert organisms. Desert ecosystems have also been considered fragile; although it is true that arid environments recover slowly from some types of disturbances, it is also true that desert organisms exhibit resilience and adaptability Most biologists consider the relative aridity and relatively low levels of soil carbon and nitrogen in deserts to be chronic stressors of organisms living there. This assumption may be more a product of man's preoccupation with agronomic land use and for his own physical comfort than of empiric inquiry.

2.5.6.2 Components of the Ecosystems on Tracts U-a and U-b

Climate. The climate of the tracts, like that of the Great Basin desert generally, is characterized by low precipitation and wide temperature ranges. Precipitation occurs for the most part during late fall, winter, and early spring, and results in a consistent annual recharge of soil moisture. Localized thunderstorms, which usually last less than one hour, provide virtually the only rainfall during the hot, dry summer and fall, but contribute little moisture of great use for net primary production. In 1975, annual precipitation on the tracts averaged 8 to 11 inches, increasing by about 3 inches for each 1,000-foot increase in elevation. About 57 percent of the mean annual precipitation occurred as snow, and 43 percent occurred as rain.

The means of diurnal temperature in 1975 ranged from 59°F to 82°F in July, and 18°F to 32°F in February. Occasionally the daily maximum was 91°F in July and the daily minimum was 7°F in February. The highest diurnal temperature recorded since 1968 was about 100°F and occurred in July or August, and the lowest nocturnal temperature recorded was -31°F in early January.

The microclimates on the tracts vary widely from place to place because of differences in topography, vegetative cover, altitude, and kinds of storms during the growing season. The influence of terrain and plant cover can be appreciated when the difference between surface temperature, soil moisture, and wind velocity beneath a shrub located on a north slope and on a bare southwest slope are considered. The interaction between abiotic components and vegetation in creating microclimates that differ markedly from the general climate of the tracts is largely responsible for the biotic diversity of the tracts.

The elevation differences contribute to microclimate variation by creating cold air drainage and temperature inversions. A surface-based inversion attributable to nocturnal ground-surface cooling usually occurs in the morning and disappears by the afternoon. The inversion in winter, spring, and fall is about twice as strong as in summer. The temperature difference between riparian areas and adjacent upland areas, which are 656 to 984 feet higher, may be as much as 18 to 20°F. Elevation on the tracts varies from about 4,800 to 5,900 feet, and the average annual maximum temperature probably occurs at about 5,580 feet.

Rainfall during the growing season tends to be sporadic and unpredictable in time, space, and intensity. A thunderstorm such as the one that occurred in July 1975, may deposit 0.8 to 1.2 inches of rain in a few hours. The heavy downpour and resulting runoff may cause severe erosion, initiate germination in annual plants, and stimulate an increase in microorganism populations while leaving areas a few miles away completely dry.

Soils. The substrate of the tracts consists of exposed bedrock, broken pieces of rock of various sizes, and soil. The percent coverage of each has not been precisely determined, but the nonsoil components of the substrate are known to be substantial. Most of the upland soils are shallow and poor from an agronomic point of view. They are low in organic material and retain moisture poorly. The only soils with any depth are under the larger plants, in valley bottoms, and along the water courses. These lowland soils have generally higher infiltration rates than those of upland soils.

Several factors combine to produce the formation of deep soils in most areas. The interaction of occasional, intense rainstorms, annual spring runoff, wind, and hilly topography of sandstone bedrock results in heavy erosion. The erosion, increased to an unknown degree by livestock, tends to cause continual sloughing of soil in the interstices between the larger plants, especially on the steeper slopes. The condition perpetuates itself, since few plants, which could reduce erosion, are able to grow in the eroding areas. From an agronomic point of view, the lack of moisture and the poor soils must be considered major limiting factors to the potential biotic productivity of the tracts.

In large measure, the soil characteristics dictate the kind of plant community an area will support. Animal communities are more reflective of the plants that directly or indirectly support them than they are of the soils. Some of the animals on the tracts, however, are directly dependent on soil type and soil depth for their existence. The habitat of the kangaroo rat, for example, is restricted to loose, sandy soil like that found along the broader washes on the tracts. The shallow, porous soils on hillsides, especially in the interstices between shrubs, support few burrowing animals, and the environment is often too dry for significant microbial activity. Bedrock offers a physical barrier to invertebrates such as harvester ants and termites that normally establish large subsurface colonies. Snakes, lizards, and ground squirrels cannot exist in

local areas where the soils are shallow. Burrows, in which they could hibernate, cannot be dug deep enough to extend below the frost line.

Microbiology. In all natural ecosystems, microorganisms have a major role in cycling nutrient, either by breaking down organic material into chemical elements, making them available to plants, or by transforming nutrients into a form usable by plants. If these processes are slowed or halted, plant growth is reduced or arrested, thus adversely affecting herbivores and carnivores in the ecosystem. Perhaps the most critical of the nutrient cycles is that of nitrogen.

Three major microbial processes contribute plant nitrogen on the tracts. The first process is nitrogen fixation by bacteria that occurs near the soil surface and in the presence of moisture. The second process is nitrogen fixation by microorganisms that live in association with the roots of certain plants. Although this phenomenon has long been associated with legumes, recent research indicates that fixation may occur generally in the root zones of desert soils. The third process is nitrogen recycling within the ecosystem. Microorganisms transform the nitrogen bound in dead animals and plant tissue to nitrates, to be reused by plants. On the tracts, this cycle is probably the most susceptible to disruption because anything that might interfere with the microbes, with the moisture necessary for their activity, or with the detritus they decompose would tend to break or slow the cycle. Although it is certain that each of these processes contributes nitrogen to the soil of the tracts, the relative amount contributed by each is unknown. The quantity of soil nitrogen present is low compared to that in agricultural land, but is about average for desert soils. Since little is known about the nitrogen requirements of native desert plants, little can be said about the adequacy of plant nitrogen on the tracts.

There is relatively little humus (carbon) in the soils of the tracts. Soil carbon is important because, as an element, it is the energy source for

microbial growth and reproduction. With carbon in short supply, the action of microbes in the decomposition process and in the production of nitrates is reduced. The carbon-nitrogen ratio in the soils of the tracts averages 8:11, and this suggests that nitrate production is limited by the scarcity of carbon. Whether or not the low level of soil carbon limits net productivity on the tracts is not known; however, it is certain that the interrelationships between factors that control the pathways and rates of biogeochemical cycles, with which microbes are inexorably bound, are among the most important on the tracts.

Plants. The tracts are situated in a salt-desert-shrub community that grades into pigmy conifer (pinyon-juniper) in the more rugged terrain. The plant communities on the tracts form a patchwork of four vegetation types with a large amount of ecotone existing between types. Patches of riparian vegetation occur in the bottomlands along the White River, and shadscale is prevalent on the rolling hills above the river. The dominant plants of the higher valleys and along the dry washes are sagebrush and greasewood. At the highest elevations and on some of the steeper slopes, juniper is the dominant plant.

Most of the larger plants on the tracts serve a function beyond their normal role as autotrophs. On slopes of anything more than a few degrees, each shrub and tree forms a barrier to the movement of soil particles and litter by wind and water erosion, and the build-up of material improves the moisture-holding characteristics of the soil around plants. Algal crusts, which contribute soil nitrogen to the system, exist on the ground beneath some of the plants. Invertebrates and microorganisms flourish in the moist litter and soil, forming detritus food chains important in soil genesis, and the enriched area beneath the large plants supports small vertebrates. In this way the biogeochemical cycles are complete within the microhabitat created by the plants.

The more a plant benefits from the microhabitat it helps to create and protect, the more the plant contributes to the habitat. Thus, a shrub that begins as a small barrier to erosion becomes the center of a small, relatively self-contained biological community complete with functions that modify the microclimate, mechanically protect the microhabitat, cycle nutrients, and transform energy.

Most of the vegetation biomass of the tracts is shrubs and pigmy conifer. These plants are widely spaced, as indicated by the 85 percent bare ground on the tracts. For the most part the bare areas, or interstices, between plants have shallow soil, low organic content, poor moisture retention capacity, and low biological activity. In the more eroded interstices, roots tend to be confined to fractures in the bedrock. Thus, the small islands of biological activity beneath tree and shrub canopies are essentially the smallest units of ecological function on the tracts; as such, their number, size, and condition are keys to the overall status of the ecological community. Any large scale factor that changes the number, size, or condition of these islands will constitute an important effect on the related area.

In addition to being widely spaced, the shrub and tree microislands are also fairly uniformly spaced on the tracts. There are perhaps three major factors influencing their dispersion. The first is competition in the interstices for water and nutrients. The second is the interdependency of the plants and the microhabitats beneath the plants that imposes biotic and abiotic limits on how large an island can be and how close one may be to another. The third factor influencing dispersion is sheep grazing. Sheep trailing through shrub community move in the interstices from shrub to shrub. This pattern promotes erosion and destroys any small plants in the interstices. The microislands themselves, however, are protected from sheep by the shrubs as long as they are not severely overgrazed.

Invertebrates. Invertebrates are important in most natural ecosystems at all consumer trophic levels. It is beyond the scope of the baseline study, and indeed of most studies, to determine the biomass and significance of even some of the common taxa on the tracts. It is important to note, however, that according to recent research, invertebrates have a much greater impact upon ecosystems than do native vertebrates. Invertebrate carnivores and herbivores probably transform more energy and cycle more material through the ecosystem per unit time than do their vertebrate counterparts.

Desert invertebrates have an especially important function in detritus food chains because they initially process dead material, a vital first step in the cycling of nutrients necessary for plant growth. Termites, harvester ants, and springtails are some of the more common organisms on the tracts. Without the activity of these invertebrates, most litter would not be available to decomposer organisms, and important biogeochemical cycles would be arrested. Disruption of the detritus food chain on the tracts would most certainly decrease the amount of nitrogen available to plants.

Desert invertebrates are also important in the diets of many of the on-tract vertebrates. Amphibians, lizards, a few snakes, and migrating birds are largely insectivorous. In addition, many herbivores and granivores, such as juncos and ground squirrels, change to a diet of invertebrates, a richer protein source, during the summer.

Some invertebrates have unique relationships with other segments of the community. On the tracts, insect pollinators are necessary for reproduction in some plants. There are also many invertebrate pest species, such as biting midges, mosquitoes, deer flies, and ectoparasites, that can be extremely annoying and could influence the seasonal activity patterns of vertebrates, including humans.

Grasshoppers and other sagebrush defoliators are numerous in some areas of the Great Basin desert and have a considerable impact on the vegetation. The tracts, however, may not have enough sagebrush and may be too botanically diverse to support heavy outbreaks of these or other defoliating insects.

Vertebrates. A diverse vertebrate fauna inhabits the tracts, as a result of the variety of habitats created by the topography and the patchy mixture of vegetation types. Beaver, whiptail lizards, and pinyon jays can be found within a few hundred yards of each other, and the number of birds per acre on the tracts is higher than in more typical desert shrub communities.

Recent desert studies indicate that native vertebrates are usually the least important component of the ecosystem from a biological standpoint. Human disturbance is more easily noticed at this trophic level, however, because of the smaller number of animals concerned. In most cases, it is difficult to measure the effect of most vertebrates species, and thus it may be of limited value to measure the amount of environmental change that would occur if deer, fence lizards, or horned larks were removed. In a reasonably balanced ecosystem, (1) vertebrate granivores collectively do not deplete the seed reserves to the extent that plant propagation is curtailed; (2) native herbivores do not significantly decrease the net productivity of plants; and (3) insectivores do not significantly limit insect populations over the long term. Native vertebrates are more apt to compete with and have an effect on like vertebrates than on other components of the biotic community. Thus, a fence lizard has more influence upon individuals of its own species than it has upon insect populations.

Some vertebrate populations have great effect upon the environment of the tracts, or have interesting interrelationships with other elements

of the biotic community. Three examples that use beavers, coyotes, and livestock are discussed in the following paragraphs:

- A small population of bank beaver lives along the White River. Their pattern of habitat use is to make a den in the river bank and feed on shrubs and small trees in an ever widening circle around the den. When the distance between the food supply and the den becomes too great for their convenience or safety, they move to another stretch of river and repeat the process. After ten or more years, beaver may return to the original area. The effect of this pattern of exploitation is to cycle secondary plant succession between early and intermediate successional stages. Beaver tend to delay or prevent the development of mature plant communities along the river, which would otherwise benefit cattle and most wildlife. Beaver may also increase the instability of river banks and the chance for the river to alter its channel.

- Coyotes are probably the most numerous and most important large vertebrate carnivores on the tracts. Their unregulated population density on the tracts is unknown, but it would probably be quite stable due to the abundance and diversity of available food. Most of the year the coyotes prey on animals whose populations do not fluctuate greatly from year to year. The tracts support no jackrabbits or microtine rodents that strongly influence coyote numbers in some areas because of their widely fluctuating populations. Coyotes on the tracts do not usually follow sheep populations. Instead, the sheep may become merely an additional and temporary food source. Control programs in the area may sharply reduce coyote populations, but probably will encourage immigration from surrounding areas and increase the reproductivity of the remaining coyotes.

- Livestock undoubtedly have a greater impact on the environment of the tracts than any other vertebrate group, including humans. Cattle remove and trample significant amounts of riparian vegetation annually, but since cattle are restricted to patches of habitat along the White River, their effect over the total area is small.

  Sheep graze extensively over most of the tracts. They tend to move in the spaces between plants and to stop at each palatable plant to eat, which removes some of

the plant material and decreases the litter available to the detritus food chains. This may or may not decrease the vigor of the plants and the minicommunities beneath them, depending on the amount of plant material removed. Sheep movement also tends to increase erosion in the plant interstices.

Although the impact of sheep on the tracts has not been documented, it appears that sheep have shifted the historic equilibrium between the factors responsible for the biotic islands and the factors responsible for the interstices. They have probably increased the shrub microisland effect by (1) increasing the number of large islands, although reducing their vigor, (2) decreasing the number of small islands, and (3) increasing the amount of bare ground between the shrubs. The removal of sheep might increase the vigor of the shrub microislands now existing, but probably would not significantly alter the current equilibrium for many years.

Aquatics. Although aquatic ecosystems within deserts occupy a much smaller part of the area than in other types of communities, evidence indicates that their importance is disproportionately large. Water in the desert, whether it is in a temporary pool, an intermittent stream, or a river, is the site of intense biological activity and provides the medium for a well-defined biotic community. Many terrestrial vertebrates need regular access to free water, and their daily dispersal patterns are governed by its availability. In addition, numerous terrestrial invertebrates and amphibians depend on surface water, since their larvae are aquatic. Groundwater is equally important because its consistent availability around permanent water sources allows the development of a unique flora with a concomitant fauna. Perhaps the most important aspect of desert water sources is that often they are the focal point of human activity and its accompanying impacts.

The White River is the largest aquatic ecosystem on the tracts. Like all large aquatic systems, it is a relatively stable environment. Water volume, temperature, nutrient availability, and light penetration change

little from day to day, and most changes that do occur follow cyclical events and are reasonably predictable. The most important of these events is spring runoff. At this time, the quantity of water increases dramatically, and the silt load of the river, which is high at any time, increases accordingly. The silt scours the riverbed and reduces light penetration, which tends to decrease primary production by removing aquatic plants from the river bottom and by reducing photosynthesis. Primary production is highest in fall when low flow and reduced silt loads result in better light penetration.

The most significant interrelationship between the river and other components of the tracts is the riparian habitat. Silt deposited from the river provides the substrate for the habitat, and water from the river maintains it. Thus, the aquatic system indirectly supports cattle, many migratory birds, trees, and other organisms unique to the riparian environment, as well as regularly transient species from upland areas.

Section 2.6

Section 2.6

HISTORIC, PREHISTORIC, AND PALEONTOLOGICAL RESOURCES

Historic, prehistoric, and paleontological resources have been inventoried and evaluated on 75 sites on or within a 1-mile perimeter of the lease tracts. The investigations were conducted under present federal and state antiquities laws using current professional standards. Dr. David B. Madsen, of the Utah Historical Society, conducted the cultural resource investigation, while Dr. Wade E. Miller, of Brigham Young University, investigated the paleontological resources.

2.6.1 HISTORIC RESOURCES

2.6.1.1 Historic Periods

Historic cultural activities in the area can be subdivided into four periods: native American, early European exploration and trade, agrarian settlement, and mineral development.

Native American Culture. Prior to the arrival of the white man, the Uinta Basin was primarily the homeland of the Ute Indians, who were divided into several closely knit bands. These nomadic groups subsisted by hunting and gathering and ranged throughout the Uinta Basin and into Western Colorado. The various Ute bands were in almost constant contact in their travels and frequently congregated for celebrations. The arrival of the first Europeans in the area marked the beginning of a series of drastic changes in the Indians' traditional way of life.

Early European Exploration and Trade. The source of the first European contacts was from the south, as Spanish explorers and traders attempted to extend their sphere of influence from Mexico. Reports of trade between Spaniards and Utes date back as early as 1712, and this trade steadily increased, despite the passage of laws in 1775 forbidding trade with Utes. The first recorded visit to the area was made by the Escalante expedition in 1776, which intensified the pressure for trading with the Indians. It was not until the 1820's, however, that the use of the Uinta Basin intensified. This increased use was caused by an influx of French and American fur trappers and traders from the east and south. The first year-round white settlement, Fort Rubidoux, was established as a trading post in 1838 and soon became the central meeting point for travelers, traders, and trappers.

The declining demand for furs and the disruption of the Mexican War brought the trading era to an end by the late 1840's.

Agrarian Settlement. The colonization of the area by Mormon settlers in the latter decades of the 19th century strongly influenced the shaping of the present economy and culture of the Uinta Basin. The first Mormons did not enter and explore the Uinta Basin until 1861, although the Wasatch Front was settled earlier.

It soon became apparent that the agrarian settlers and the Ute inhabitants were in direct competition throughout the state for the limited resources available. Following the Walker War in 1854, the Uintah Reservation was established in the Uinta Basin at the request of the settlers. The Utes refused to move to the reservation, leading to the renewal of hostilities from 1864 to 1869 (the Black Hawk War). Following their defeat, the Indians were finally removed to the reservation.

The 1870's decade was marked by the establishment of an Ashley Valley settlement, which later became Vernal. Several communities evolved in the surrounding area — Naples, Maeser, Jensen, Hallsville — and in 1886 a stake of the Church of Jesus Christ of Latter Day Saints was founded in Vernal.

During this settlement period, Uncompaghre Ute uprisings in Western Colorado led to their transfer to the Uintah Reservation and the creation in 1881 of the Uncompaghre Reservation. Fort Thornburgh was established to protect the area but was abandoned 3 years later. Fort Duchesne, founded in 1886, was more successful and became a permanent settlement.

Mineral Development. The second most important influence on the evolution of the Uinta Basin has been the discovery and development of the area's rich mineral resources. The discovery of gilsonite in the late 1800's led to the removal of a portion of the Uintah Reservation and mounting pressure for opening of the Indian land to white development. Finally, in 1895, the process of allotting 160-acre homesteads to the Indians began, so that the remainder of the reservation could be opened for mineral development. At the same time the two reservations were combined into what is now known as the Uintah and Ouray Reservation. The reservation was officially opened for settlement by President Roosevelt in 1905.

The rapid development of Gilsonite mining in the basin and the opening of several small mines in Colorado led to the organization of the Uintah Railway to transport the ore over the Book Cliff Mountains to Mack, Colorado, where the line would connect with the Denver & Rio Grande Western Railroad. Following completion of the railroad in 1904, a toll road was built from the northern terminus at Watson to Vernal, with

a series of stage stops in between. Two of these stations were located just north of Tracts U-a and U-b at Ignacio and Bonanza.

The opening of the reservation lands precipitated a new wave of settlement. New towns and small farming communities sprang up and a second stake of the Mormon Church was established at Fort Duchesne in 1910. Duchesne County was created in 1915. In 1933, additional land was withdrawn from the Uintah Reservation under the Taylor Grazing Act. In 1950, $17,000,000 was awarded to the Uintah and Uncompahgre Tribes as compensation for their losses. An additional $7,000,000 was received in 1960. These funds have since been used to support tribal development programs.

Although Gilsonite activities had declined in the Uinta Basin by the 1930's (with the exception of the American Gilsonite mine at Bonanza), energy-related development has had continued importance in the economic development of the area. Oil and gas exploration and production has been a major activity since the 1950's. Recently, interest has turned to extraction of oil from tar sands and oil shale, more specifically on Tracts U-a and U-b south of Bonanza. Full-scale commercial development of these resources could signify the beginning of another major period of development in the Uinta Basin.

2.6.1.2 Historic Components

Use of the area around the oil shale Tracts U-a and U-b by the Ute Indians was limited. Although Indians are known to have traversed the White River, no trails were found in the study area. No evidence of other Ute cultural sites was revealed by archival research or the resource inventory.

The Ignacio Stage Station was the only major historic site on or near the study area identified in the investigations. A series of stage stops was constructed along the Uintah Railway toll road. The Ignacio Station, built in 1905, was the first stop north of the railroad terminus at Watson. The stage route followed Evacuation Creek while the station and bridge across the White River were being built. Many of the buildings at the Ignacio Station still remain, but they are in poor condition.

Other sites located during the investigation include a number of small cabins built by homesteaders in the early 1920's. These cabins are in poor condition or beyond repair.

2.6.1.3 Historic Significance

The most important historic feature on or near Tracts U-a and U-b is the Ignacio Stage Station. This site has been nominated for inclusion in the National Register of Historic Places by the Utah Historical Society. Although the remaining structures at the site are in poor condition, they are a good example of the type of architecture used in this part of the late frontier.

2.6.2 PREHISTORIC RESOURCES

The investigations have identified both expected and unexpected prehistoric resources in the study area. The resources consist of open sites and rock shelters that contain various types of artifacts and cultural remains of three to possibly five prehistoric cultures. Most of the sites are located along the White River. The located resources also support previous interpretations of Uinta Basin prehistory as well as suggesting new ones.

2.6.2.1 Prehistoric Occupants

The prehistoric resources indicate intermittent occupation of the study area from approximately 2225 B.C. to 1125 A.D. by hunter-gatherers and incipient agriculturalists similar to those of the prehistoric Great Basin and Colorado Plateau cultures. These resources also indicate influence from, or occupation by, Plains hunter-gatherers and agriculturalists. Paleo-Indian "big-game" hunters and Numic cultural traditions of the Shoshonian linguistic family, circa. 1300 A.D. to recent times, are not represented in the artifacts collection. Evidence for the presence of Fremont agriculturalists is inconclusive at this time. Earlier cultures may have been present in the study area, however, as many of the sites indicate subsurface cultural deposits.

2.6.2.2 Prehistoric Components

The prehistoric sites have been classified by the investigators as either open sites or rock shelters. Because of poor surface conditions, no functional uses of the sites, such as habitation or tool manufacturing, were discernible. Of the 32 sites inventoried, 25 were located within one-half mile of the White River. Seven sites were located on the tracts and 25 off the tracts. The characteristics of the sites are summarized in Table 2.6-1.

2.6.2.3 Significance of Prehistoric Resources

The significance of the prehistoric resources was not firmly established during the baseline survey. The disturbed surface conditions of the site locations and the poor understanding of Uinta Basin prehistory preclude final evaluation without subsurface test excavations of the more promising sites. For a further discussion of this program refer to Section 4.8.

Table 2.6-1

PREHISTORIC RESOURCE INVENTORY

Site	Condition	Description	Land Ownership
On-Tract Sites			
42 Un 372	Undisturbed	Open site: surface scatter of lithic chipping debris — 100 m diameter	BLM
42 Un 373	Possible surface collections made previously	Open site: chipped stone and fire-cracked river cobbles — 100 x 100 ft	BLM
42 Un 324	Undisturbed	Rock shelter: lithic chips, bone, charcoal — 130 x 12 ft	BLM
42 Un 408	Some potholes	Open site: single flake ca. 10-15 m length	BLM
42 Un 409	Probable surface collections made previously; some erosion	Rock shelter: 2 fire stains, possible depth of deposit — 5 x 5 m	BLM
42 Un 405	Probable some surface collections	Open site: chipping debris, sandstone slabs wall, three shallow pits — 100 x 200 m	BLM
42 Un 406	Eroded	Open site: bifaces, hammerstone, historic debitage — 100 m	BLM
Off-Tract Sites			
42 Un 118	Extensively vandalized but some undisturbed deposits remaining	Rock shelter: charcoal lenses and burned soil, corn cobs, chipping debris, charred animal bones, possible 2-m depth — 50 x 15 m	State
42 Un 355	Undisturbed	Rockshelter: surface scatter of fine chips, one notched point — 8 x 60 ft	BLM
42 Un 356	Eroded	Open site: surface scatter of chipping debris — 25-m diameter	State

Table 2.6-1 (continued)

Site	Condition	Description	Land Ownership
Off-Tract Sites (continued)			
42 Un 357	Eroded	Open site: chipping debris and single projected point — 5-m diameter	State
42 Un 358	Eroded	Open site: single projectile point	State
42 Un 365	No apparent potholes; shelter has been littered with historic debris	Rock shelter: masonry granary, one projectile point, burned bone, charcoal	State
42 Un 366	Extensively potholed	Rock shelter pictographs, flakes, and chipping debris	State
42 Un 367	Potholed; one 3 ft strip of deposit remains undisturbed; 10 ft long	Rock shelter: flakes and chipping debris	State
42 Un 368	Undisturbed	Open site: chipping debris, one blade — 200 ft x 100 ft	BLM
42 Un 369	Picked over but no potholes	Open site: chipping debris, fire-cracked cobbles — 300 x 200 ft	BLM
42 Un 370	Undisturbed	Open site: chipping debris, fire-cracked cobbles — 300 x 100 ft	BLM
42 Un 371	Undisturbed	Open site: fire-blackened cobbles, etched slate petroglyph	BLM
42 Un 374	Surface picked over; no potholes	Open site: chipped stone, fire-cracked and blackened cobbles — 100 x 100 ft	BLM
42 Un 375	No obvious potholes	Open site: debris and fire-cracked cobbles — 100 x 150 ft	BLM
42 Un 376	Undisturbed	Open site: chipping debris, projectile points — 20 x 20 ft	Private

Table 2.6-1 (continued)

Site	Condition	Description	Land Ownership
Off-Tract Sites (continued)			
42 Un 377 (Thompson site)	Almost totally vandalized	Open site: considerable depth with charcoal, chipping debris, and fire-blackened cobbles	BLM
42 Un 378	No potholes but probably picked over	Open site: lithic debris — 200 x 200 ft	BLM
42 Un 379	Eroded	Open site: chipping debris and core fragments	BLM
42 Un 380	Eroded	Open site: one projectile point	BLM
42 Un 381	Potholed	Rock shelter: chipping debris	BLM
42 Un 401	Some potting but mostly undisturbed	Open site: lithic debris, pottery, gray stone	State
42 Un 402	Some potholes but good general condition	Rock shelter: flakes, scrapes, bifaces, and choppers	BLM
42 Un 403	Good	Pictograph	BLM
42 Un 404	Eroded	Rock shelter: possible projectile point or knife	BLM
42 Un 407	Potholes	Rock shelter: charcoal and chipping debris exposed by potholes — 150 x 10 ft	BLM

2.6.3 PALEONTOLOGICAL

Most sections in the study area were found to contain at least some fossils. Identified fossils include leaf imprints and impressions, petrified wood, insects in larval and adult forms, fish scales and bones, turtle shells, crocodile teeth and bones, and mammalian teeth and bones. These fossil resources represent a valuable record of paleo-environments of the Eocene Epoch in the Uinta Basin.

2.6.3.1 Paleontological Periods

The exposed strata consist of alluvial (stream-related) and lacustrine (lake) deposits. A study of the floral and faunal assemblages in these strata reveals that these assemblages inhabited a region whose climate was warm and humid.

The primary formations involved are, in ascending order, the Green River and Uinta Formations. These formations have yielded an abundance of fossils in many areas within the Uinta Basin.

The Uinta Formation, composed of sandstones, represents the youngest strata. It is rich in hydrocarbons, the remains of the mostly microscopic life that existed in the Eocene lakes, and, in addition, it contains a great number of megascopic fossils, which attest to the richness of life forms that lived in and adjacent to the ancient Green River Lakes.

The Green River Formation has special scientific importance because its fine-grained sediments and quiet-water deposition have allowed fine details of fossils, usually lost, to be preserved. Veination in leaves, insect wings, and even insect tracks can be clearly seen.

2.6.3.2 Paleontological Components

Fossils occurring in the study area are listed in Table 2.6-2. Leaf material, some petrified wood, insects, and fish were found in the Green River Formation; and additional petrified wood, turtle, crocodile, and mammalian specimens were found in the Uinta Formation. With the exception of algae, plant fossils consist of angiosperms (flowering plants). Fossil insects consist mostly of flies, the bulk of which are in larval form. All identified fish remains are of a freshwater gar pike. The identified mammal specimens belong to several types of brontothere (an extinct relative of the rhinoceros).

A wide variety of insect fossils have been identified in and adjacent to Tracts U-a and U-b. Fish remains were surprisingly scarce. Only scales and occasional fragmental bones were found. Although more than one type of fish is represented, only the gar pike could be identified. Collected turtle specimens have not yet been sufficiently prepared for identification, although probably more than one genus is represented in the area. Several teeth of a crocodilian evidently belong to the genus Allognathosuchus. Although some unidentified bone fragments may belong to a uintathere (a large mammal of the order Dinocerata), the only identified type of mammal is a brontothere (titanothere), or thunder beast.

Table 2.6-2

PALEONTOLOGICAL RESOURCE INVENTORY

Site	Fossil Types	Geological Formations	Significant
On-Tract Sites			
1	Unidentifiable plant debris	Uinta	No
2	Unidentifiable plant debris	Uinta	No
3	Fragmental plant remains	Green River	No
4	Unidentifiable Plant debris	Lower Uinta, Upper Green River	
5	Fragmental plants, some complete leaves	Green River	Yes
6	Unidentifiable plant debris	Lower Uinta, Upper Green River	No
8	Fragmental plants, some complete leaves	Green River	Yes
9	Fish scales, leaves	Green River	Yes
20	Turtle shell and bone, plant fragments	Uinta	Yes
23	Turtle shell fragments, wood	Uinta	No
24	Brontothere teeth, turtle shell	Uinta	Yes
28	Brontothere bone, petrified wood	Uinta	Yes
29	Petrified wood	Uinta	No
30	Turtle shell fragments	Uinta	No
32	Unidentifiable bone fragments	Uinta	No
34	Fish scales	Green River	No
35	Wood fragments	Uinta	No
36	Wood fragments	Uinta	No
Off-Tract Sites			
7	Insects, leaves	Green River	Yes
10	Unidentifiable wood fragments	Uinta	No
11	Insects	Green River	Yes

Table 2.6-2 (continued)

Site	Fossil Types	Geological Formations	Significant
Off-Tract Sites (continued)			
12	Insects	Green River	Yes
13	Wood fragments	Uinta	No
14	Insects, plant fragments, some leaves	Green River	Yes
15 a,b,c	Insects, plant fragments	Green River	No (a,b) Yes (c)
16	Insects, plant fragments, seeds	Green River	Yes
17	Insects	Green River	Yes
18	Plant fragments, some complete leaves	Uinta	Yes
19	Plant fragments, some complete leaves	Lower Uinta, Upper Green River	Yes
21	Some petrified wood	Uinta	No
22	Brontothere bones, turtle shell	Uinta	Yes
25	Petrified wood	Uinta	No
26	Brontothere teeth, turtle shell fragments	Uinta	Yes
27	Petrified wood	Uinta	No
31	Brontothere teeth and bones	Uinta	Yes
33	Petrified wood	Uinta	No
37	Fragmental plants, some complete leaves	Uinta	No
38	Fragmental plants, some complete leaves	Uinta	No
39	Brontothere teeth and bones, alligator teeth, turtle shell	Uinta	Yes

2.6.3.3 Paleontological Significance

These fossils are considered scientifically important: they yield valuable information on early climatological conditions, early environments, and evolutionary processes. In some instances, it may be possible to determine the place of origin for types of plants and animals. The most significant fossils found during the survey were those of insects and brontotheres. The plant fossils are important because such an abundance of well-preserved specimens is relatively rare in the fossil record; the animal fossils are important because of their usefulness in dating and in evolutionary studies.

The most significant paleontological sites are located off tract, north of the White River. The on-tract resources are, for the most part, petrified wood and plant fossils. Only a sampling of the most important on-tract specimens will be required prior to any construction activities, as described in Section 4.8.

Section 2.7

Section 2.7

AESTHETICS

Aesthetic features for a land mass are considered to be the physical and cultural elements of landscape for an area perceived by humans through the senses. These elements of landscape are moderated by human feelings through emotional, cognitive, and evaluative judgments. The primary guide for any judgment of aesthetics is beauty. In brief, beauty is that aggregate of qualities in a person or thing that promotes harmony. For the purpose of this study, aesthetic features are defined herein narrowly in terms of landscape units. A landscape unit is an area of land possessing similar, yet distinguishing visual characteristics of landform, rock formations, water surfaces, and vegetative patterns.

2.7.1 THE REGIONAL AESTHETIC SETTING

The boundary landforms around the Uinta Basin are the primary aesthetic features of the region. The most accessible of these are the Uinta Mountains, Book Cliffs, Wasatch Plateau, Flaming Gorge National Recreation Area, Dinosaur National Monument, and Green River. The area is known as "red rock country," indicating the dominantly perceived color. Distant views are common, and sounds are nonirritating because of few urban-industrial influences. Dust, daily extremes in temperature, and dryness influence the perception of the natural features of the area.

Tracts U-a and U-b and a 1-mile border area were divided into three mappable units that are identified as the ridgetop-basin landscape unit, the canyon landscape unit, and the White River landscape unit.

2.7.2 THE RIDGETOP-BASIN LANDSCAPE UNIT

The ridgetop-basin complex includes areas with panoramic views of the surrounding landscape. The distinct contrast between the brown-to-buff-colored Uinta Formation and the different strata of the underlying Green River Formation is apparent from this unit. The views are so distant that the aesthetic experience is primarily visual. In contrast to the panoramic views, the ridgetop setting is dominated by unusual micro-landforms, such as lichens, ancient ripple marks, precipitation cusps in rock, honeycombed appearance of some calcareous rock, and seedling pinyon trees. Mammals, birds, and small reptiles are frequently seen. Numerous rock pinnacles, waterpockets, balanced rocks, and rock windows are prominent geologic features of the unit. Shallow rock depressions on the mesa tops add variety to the appearance of the ridgetop-basin landscape unit.

2.7.3 THE CANYON LANDSCAPE UNIT

The canyon landscape unit includes Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. Because the water-land interface is such a dominant element in White River Canyon, this area will be considered separately. The canyon landscape unit is characterized by enclosed views enhanced by geologic detail, microchanges in vegetation, and water in ephemeral stream courses. Evacuation Creek Canyon has many unusual cavities along the rock walls below the protruding ledges that give a coarse, honeycombed appearance to the canyon. The nearly vertical walls direct attention toward the canyon and along the sharp boundary between the walls and the usually clear Utah sky. A distinctive white bed of volcanic ash is visible along the walls of Evacuation Creek. Small pools are formed when relatively clear groundwater seeps through the sand or along the edge of the creekbed.

Desert varnish, composed of the reds, blues, and blacks of oxides of iron and manganese, gives the canyon walls and overhanging ledges a variegated appearance. Mudflows have also added to the streaked appearance on the walls.

Evacuation Creek differs from other canyon landscape units in its more confined views, more frequent stream flow, and greater diversity of vegetation types, including the more colorful riparian associations. Southam Canyon has fewer enclosed views, while Asphalt Wash has fewer meanders and lies in a more symmetrical valley than does Evacuation Creek. Deviations made by humans include dirt roads along Southam Canyon and Asphalt Wash, and an occasional deserted corral.

2.7.4 THE WHITE RIVER LANDSCAPE UNIT

Since the White River is the most prominent feature and the only perennial stream on the project area, it is considered as a separate landscape unit. The views are characteristically enclosed within the limits of White River Canyon; however, considerable detail and movement may be observed from the river itself. The canyon walls are usually steep and are composed in places of stream-cut facets with large vertical relief and vertical joint and fracture lines superimposed on the horizontal stratifications. The land-water interface along the river is a continuation of point bars protruding from the canyon walls and cut banks on the opposite side of the river. Thinly laminated silt beds on the bars, and alluvial deposits of various sizes exposed on the cut banks reveal a cross section of the river's history. Rock ledges, windows, rock alcoves, and recent rockfalls are common. The highest ridge visible from the river is in sharp and jagged contrast with the sky.

Channel bars, snags, and driftwood are common in the river. Beaver dams and their occupants are sometimes seen. Lower point bars show evidence of meander scars that emphasize the sinusoidal nature of the

channel pattern. Many of the more stable point bars are thickly vegetated with green cottonwoods. Cattle frequently occupy these riparian areas, and deer are occasionally observed, particularly east of Ignacio Bridge.

Many small insects, grasshoppers, and garter snakes appear frequently along the stream banks. Ducks, various shorebirds, and raptors also add variety to the aesthetic setting. The river is extremely turbid, yet reflected sunlight seen from the bridge, or from the riffles during sunrise give a pleasing contrast. At sunset, long shadows on the river, emphasize ridgeform and vegetation shapes.

There are two seasonal changes in the White River that greatly alter the landscape appearance. In the winter, the river freezes and forms a white band of ice that winds through the canyon. In the fall, some riparian vegetation turns various shades of red, orange, and yellow, and contrasts with evergreen shrubs and trees.

Section 3.1

Section 3.1

INTRODUCTION

Part 3 summarizes the most probable action proposed for the White River Shale Project. The description of the project's mode of development and facilities presented herein does not include a discussion of the alternatives, an evaluation of environmental impacts, or the procedures White River is proposing to mitigate these impacts. These elements of the White River Shale Project are discussed in Part 7, "Alternatives and Selection Rationale," Part 4, "Planned Environmental Protection Procedures," and Part 5, "Environmental Effects of the Proposed Action After Mitigation."

Section 3.2

Section 3.2

OBJECTIVES

3.2.1 NEW ENERGY SOURCES

The White River Shale Project is designed to implement the federal oil shale prototype program for stimulating private industry to produce commercial quantities of oil from shale. This step toward national energy independence can be taken once the technical and economic risks are reduced to a level that can attract investment capital.

3.2.2 RESOURCE RECOVERY

In planning the proposed action, a prime requirement was that the resources be recovered in a way that represents the best return to all interested parties.

3.2.3 ENVIRONMENTAL PROTECTION

The White River Shale Project will be developed in a manner to ensure that the environmental integrity of the area is maintained to the greatest degree possible.

Section 3.3

Section 3.3

SUMMARY AND SCHEDULE OF PROJECT DEVELOPMENT

3.3.1 INTRODUCTION

This section provides a summary of the proposed action described in Part 3. It summarizes the most probable plan for mine development and for construction and operation of aboveground shale oil production facilities. The summary is limited to the physical actions to be taken and the physical facilities that will result. Environmental protection procedures and environmental impacts are discussed in Parts 4 and 5. Alternatives are discussed in Part 7. A summary of the overall development schedule for the White River Shale Project is discussed below. More detail is found in the subsequent sections.

3.3.2 OVERALL DEVELOPMENT SCHEDULE

The overall development schedule is presented in Figure 3.3-1. As shown in the schedule, development will begin with a program to obtain geotechnical data for final mine design and to provide a bulk sample for retort and crusher confirmation. This program will be referred to as Phase I. Work on a mine opening could start in the second half of the second project year; the mine opening will be completed about 6 months later, and Phase I mining will start at that time, continuing for several months. The retort and crusher testing using bulk samples of shale from the access mine will be conducted at existing facilities located off tract. The data from these tests will be used as input to Phase II engineering.

Phase I will be followed by Phase II — the development of a single commercial sized retort along with working mine and ancillary facilities. Engineering for this phase will start during the third quarter of Year 2 and

continue for about 10 months. Mine development and construction of aboveground facilities for this phase will take place concurrently, starting, respectively, in the last quarter of Year 2 and about the beginning of Year 3, and taking approximately 3 years to complete. At that time (Year 6), mining will begin and startup of aboveground facilities will be initiated. The startup period will require about 6 months, after which full operation of the Phase II mine and aboveground facilities will proceed for approximately 2 years. At the end of this period (middle of Year 8), Phase II operation may be curtailed.

Phase II will be followed by Phases III and IV — the commercial operation. Engineering for this phase will start at about the beginning of Year 8 and continue through the first quarter of Year 9. Mine development will also start at about the beginning of Year 8, and construction of aboveground facilities will start about 6 months later. Phase III — first-train startup and mine production for support of the first train — will be initiated about the beginning of Year 11, with full capacity operation about 6 months later. Phase IV — second-train startup and supporting mine production for the second train — will be initiated about the middle of Year 12, with full-capacity operation about 6 months later. Both trains will continue full-capacity operation to depletion of oil shale reserves, at which time the entire facility will be decommissioned and abandoned. These decommissioning and abandonment plans are discussed in Section 3.21.

The schedule described here is based on present knowledge of oil shale mining and processing. Naturally, knowledge gained later, especially during Phase I and Phase II, together with regulatory and economic changes that can occur during early project activities, will have a profound effect on the total schedule.

3.3.3 EXPLORATORY, BASELINE, AND PRELIMINARY STUDIES

In the overall White River Shale Project program, one of the early stages was exploratory work on Tracts U-a and U-b. It was primarily a program

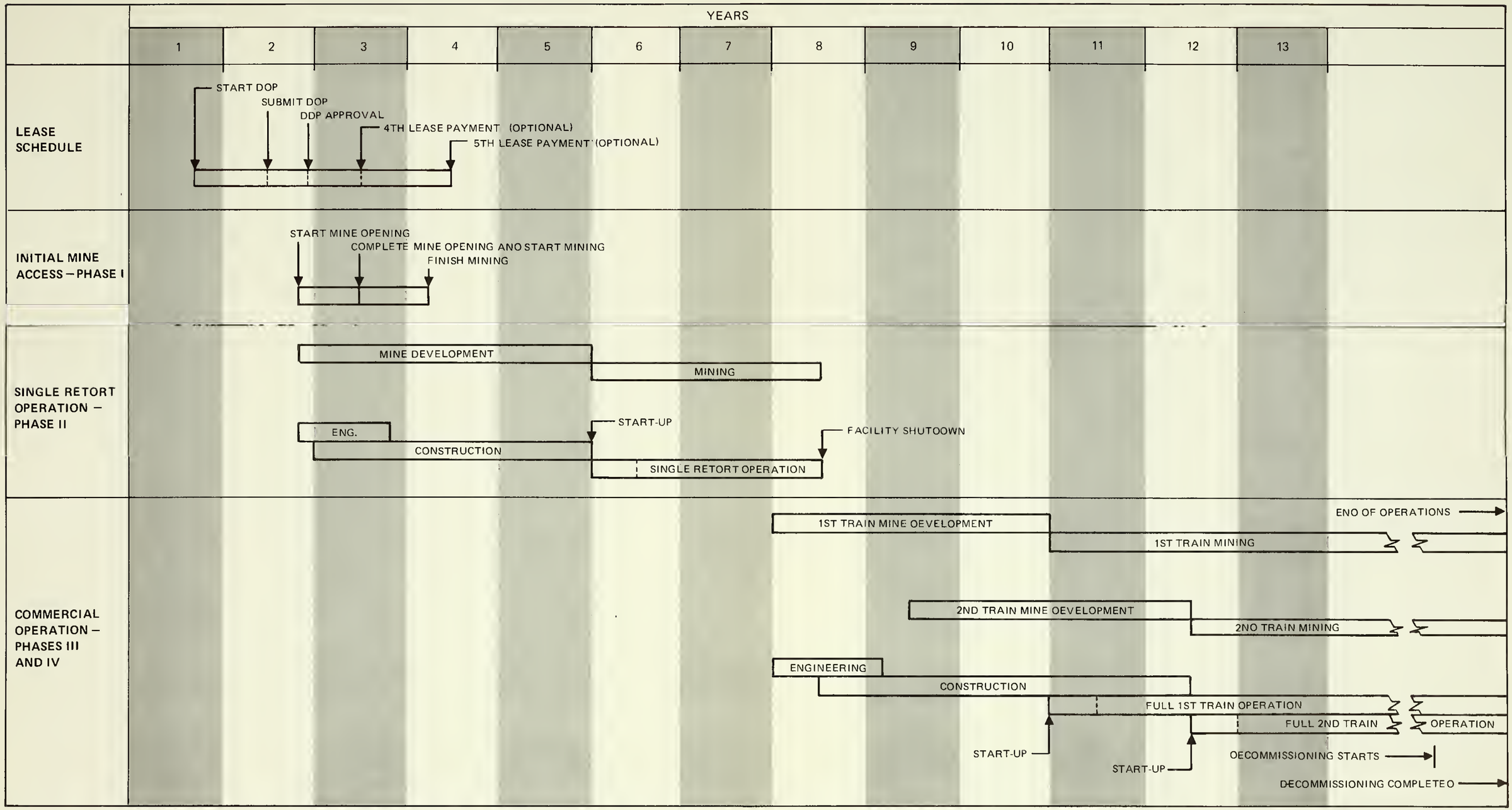


Figure 3.3-1. White River Shale Project Development Schedule

of core drilling and geologic examination to establish the principal characteristics of the oil shale mining zone and the material lying above it.

In a companion program carried on in various engineering offices, a series of preliminary conceptual engineering designs and plans of operation for mining and processing were developed.

The results of these field investigations and engineering designs are summarized in Part 7, "Alternatives and Selection Rationale," and in the present Part 3, "Description of the Proposed Action," in which the White River Shale Project is summarized as a most probable plan to be followed for development and operation.

In a parallel program, White River Shale Project pursued a program of developing baseline environmental data as relevant to Tracts U-a and U-b. This information is presented in a condensed form in Part 2, "Description of Project Area," and is summarized more fully in the First Year Environmental Baseline Report (Ref. 7) prepared by VTN, Denver, which accompanies this Detailed Development Plan.

3.3.4 LAYOUT OF FACILITIES

The specific location of Tracts U-a and U-b in northeast Utah makes it necessary that operations fit already existent broad transportation and logistic patterns. A study of the area indicates that the nearest available railhead for receipt of material for this project is at Craig, Colorado. Establishing rail spurs that would come closer to the site has been judged impractical at this time. Transportation from Craig will be by truck over existing highway systems, and it may be necessary to upgrade portions of this system. These questions are discussed at greater length in other portions of this Detailed Development Plan. An area map indicating the transportation routes is shown in Figure 3.3-2.

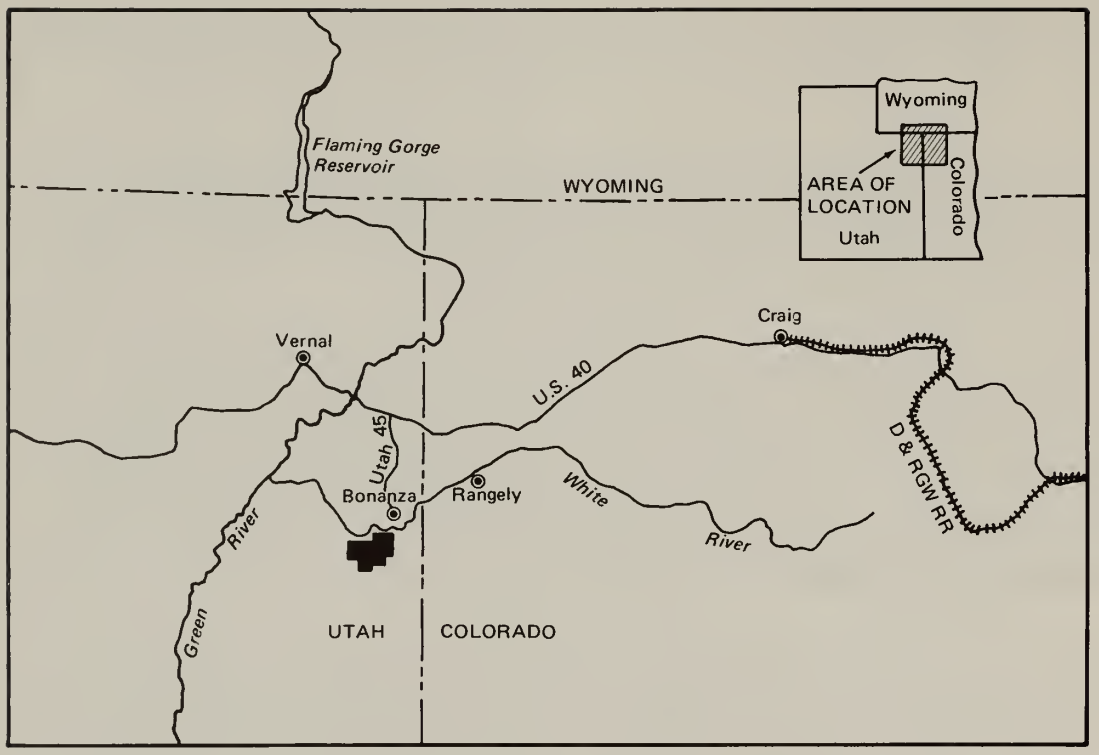


Figure 3.3-2. Area Map

Personnel required during the construction period of this project, both mine development and facility construction, will be drawn from a relatively wide area because there is not adequate labor nearby. It will be necessary to establish camp facilities since existing residential provisions in the area are not adequate for accommodating the level of manpower needed at this project. In order to minimize travel and lost time, it is presently planned that the construction camp will be in the vicinity of Bonanza, about 10 miles from the site.

The supply of water will come from the White River, either through a well system or a more elaborate pumping system based on backing up water behind a dam to be built on the White River. These facilities are within easy reach of the tracts, requiring a pipeline no more than 2 miles in length.

Electric power for this project will be available from Moon Lake Electric Association, Inc., on a power grid that now exists and can be extended to

the jobsite. As power requirements increase and exceed the capability of this grid, it is most probable that Moon Lake will go through one minor expansion of delivery capability, after which White River Shale Project will become self-sufficient in power generation.

The layout of facilities and the use of ground area on these tracts are reasonably confined by the nature of the project and the terrain of the tracts. The largest single dedication of area relates to shale disposal after retorting. Consideration of tract terrain and environmental impact resulted in the choice of Southam Canyon for the disposal of the processed shale. It is felt that the overall environmental effect will be least if processed shale is disposed of in Southam Canyon.

The underground operations must remove shale of required quality from the area of the two tracts, subject to boundary provisions, pillar provisions, and the requirement for a significant block support under the process area built on the surface. The choice of mine portals and ventilation shafts has been related to the disposition of the ore underground in order to minimize the movement of materials underground, with attendant problems of dust, equipment requirements, and hauling costs.

The choice of location of the process facilities site on the surface is related to the underground operations and accessibility to Southam Canyon, again to minimize unnecessary movement of materials. In any event, a significant amount of blasting and leveling will be necessary because there is no large, level plot available on the tracts suitable for operations, as required. The proposed plan minimizes the removal of surface material through a program of terracing the process area to conform as far as possible to natural elevations. The location of tankage and support buildings has been dictated by the availability of naturally available small areas suitable for these purposes. Efforts have been made to minimize the amount of site preparation, environmental effects, and costs while assuring a high level of safety and fire protection.

3.3.5 MINING

The mining of oil shale from Tracts U-a and U-b will require approximately 10 years for full development; the development of a mine property underground must proceed in an organized, orderly fashion, and there are real limits to the speed with which the necessary equipment can be moved into space that has been provided by earlier operations.

3.3.5.1 Phase I

The White River Shale Project program starts with the sinking of a small access shaft, which will be driven vertically to the oil shale level approximately 1,100 feet below the surface of the ground. A small-diameter ventilation-escape shaft will also be sunk. Horizontal entries will be driven from this location to start the study of problems relating to mine design, and mining operations will be examined with an eye toward finalizing the approach to be used during the single retort and final commercial operation phases. These factors are discussed more fully in Section 3.5.

3.3.5.2 Phase II

After the access shaft and its operations have been fully utilized — in approximately 2 years — the mining operation will be expanded. The most probable plan calls for sinking a new shaft to the level of the ore; this shaft will allow delivery of more material to the surface than did the access shaft. The access shaft will be converted to an emergency escape shaft, required for safe operation of the mine, and the initial ventilation shaft will be enlarged.

In this second phase, there will be sufficient capacity to furnish raw shale to operate one vertical retort, which is to be built in this phase of the program. Up to 10,000 tons per day (TPD) of shale will be mined. The mining method will be room and pillar, a proven procedure, which

will be adapted to the mining of oil shale through information and designs developed during the earlier program. Phase II development of the White River program will require approximately 4 years for completion.

3.3.5.3 Phases III and IV

Before construction of the commercial plant starts, design and early operations to open new portions of the underground ore deposits must begin because of the lead time required (1) to develop sufficient mining faces to allow an adequate rate of mining and (2) to establish transportation and crushing facilities underground. Early production from these operations will be stockpiled on the surface and in previously mined-out panels. This stockpile will ensure uniform operations of the retorting and upgrading facilities to be built on the surface. The timing of mining development and of facilities construction on the surface must be carefully adjusted so that these productive capabilities become available essentially at the same time. The quantity of shale to be mined is about 80,000 TPD in support of the first train of the commercial plant, increasing to about 160,000 TPD as the second train reaches full operation.

3.3.6 FEED PREPARATION AND TRANSPORTATION

The process readying the mined oil shale for retorting will require facilities for crushing, screening, storing raw shale, and feeding the retorts. Two stages of crushing operations will take place before retorting. Preparation of the oil shale feed will begin with the primary crushing stations located underground at the mining level. Secondary crushing will take place on the surface, near the retorts. The type of retort used will determine the size to which the oil shale must be crushed. Covered conveyors will transport oil shale to crushers, the stockpile area, bins, and retort feed hoppers, and, finally, will move the processed shale to bin loadout points for final truck disposal.

Primary crushed oil shale will be stockpiled at a location between the primary crusher and secondary crushing plant to ensure uninterrupted operation of the secondary crusher and continuous feed to the retorts. The mine haulage system and primary crushing operations will be interdependent. If the primary crusher is shut down, haulage from the mine will be stopped, and the secondary crusher will then be fed from the stockpile.

3.3.7 RETORTING

A two-stage program has been planned to achieve a full-scale shale oil production facility. The two stages are: single retort operation and commercial operation. These correspond to Phase II and Phases III and IV respectively.

The objectives of the single retort operation stage will be to evaluate and assess retort technology and related mining, crushing, and material handling operations and their environmental impacts. During this stage, a single vertical-type retort will be installed and operated.

Upon successful completion of the single retort stage, the commercial operation stage will begin. Additional vertical-type direct heated (DH) retorts, along with indirect heated (IH) retorts and fines-type retorts, will be installed to meet the equipment requirements for commercial plant operation. The commercial operation stage will take place in two steps: a first train will be built; a second train will be added to the first train to complete the final full-scale commercial plant. The first train, which will permit operation at 50 percent of capacity, will include the original retort installed during the single retort operation stage. The final full-scale plant will contain about 20 retorts.

The single retort operation stage is aimed at evaluating the vertical-type retort. In line with this aim, no facilities will be installed for upgrading the crude shale oil produced. Furthermore, any fines produced during

crushing and screening of the raw shale will be discarded if they are not economically recoverable. The quantity of fines involved will be determined in Phase II operation.

The commercial operation stage will include provisions for upgrading shale oil and utilizing fines. The use of three different types of retorts — DH, IH, and fines-type — has been based on specific process needs, coupled with the requirement for high operating and thermal efficiency. Since the vertical-type retorts (both DH and IH) may not be able to handle fines, fines-type retorts will be required so that the fines produced during raw shale crushing and screening can be processed rather than discarded.

The crude shale oil produced by the retorts will be upgraded by hydrotreating, which will require a supply of hydrogen. The commercial facility will include a hydrogen plant for manufacture of this material. Feed for the hydrogen plant will be high-Btu gas. In addition to processing fines, the fines-type retorts generate high-Btu gas which, after treating, is suitable for hydrogen plant feed. However, the quantity of gas produced by the retorting of fines is not sufficient to satisfy the needs of the hydrogen plant. The vertical-type retorts, when operated in the IH mode, also generate high-Btu gas which, after treating, is satisfactory for hydrogen plant feed. Therefore, in the design of the commercial plant, IH retorts are included to provide sufficient capacity for generating the required high-Btu gas for the hydrogen plant.

3.3.8 UPGRADING

The upgrading process design is based on a two-train or dual-plant concept, which will permit operating flexibility and ensure continuity of operations. The two trains will be installed sequentially with a delay of approximately 2-1/2 years between completion of the trains. Startup of the first train will permit 50 percent capacity operation, with a 50 percent

turndown ratio to a 25 percent minimum operating level. The second train startup about 30 months later will give 100 percent capacity operation potential with 75 percent turndown flexibility.

The 100,000 BPCD of crude shale oil produced by retorting will be processed in two parallel hydrotreating units followed by additional naphtha hydrotreatment, to yield 107,560 BPCD of C_5^+ refined shale oil. Some refined shale oil will be used as process and utility plant fuel, and a small amount will supply the requirements for diesel fuel in the mining operation. The net yield of refined shale oil product will be 96,000 BPCD.

Supporting process facilities will consist of light ends compression, hydrogen production, amine gas treating, sulfur recovery and tail gas treating, wastewater treating, and sour water stripping. Supporting offsite facilities will comprise storage, product movement, relief and blowdown, utilities, water supply, wastewater treatment, solid waste handling, and maintenance and administrative facilities.

After the facility process fuel and hydrogen plant feed requirements are furnished, there will be a surplus of low-Btu gas. This gas, together with upgraded shale oil, will be used to generate the power required by the facility. With the exception of raw water, the oil shale facility will not require purchased utilities under normal circumstances.

3.3.9 SOILS HANDLING

Construction of project facilities will cause little surface disturbance to Tracts U-a and U-b. The relatively small quantity of overburden that will result will have too high an organic content to be suitable for use in construction, but it may be valuable in site rehabilitation and revegetation. Some of this material will be segregated and stored for future use.

3.3.10 PROCESSED AND RAW SHALE DISPOSITION

The disposition of processed shale from the retorts represents one of the major problems to be dealt with in the White River Shale Project. There are no commercial operations of this kind presently in operation; hence, the conceptual plans presented herein must be regarded as the best thinking developed to date. The White River Shale Project is a phased program of orderly development that includes a relatively small-scale beginning phase during which the techniques for disposing of large quantities of processed shale will be perfected.

The geographic configuration of Tracts U-a and U-b and environmental considerations make Southam Canyon the preferred place for disposition of processed shale. This Detailed Development Plan describes an orderly program containing a relatively definitive set of stages, wherein processed shale is moved to and placed in Southam Canyon. This program will permit revegetation at an early date in a continuing program following startup of the plant.

3.3.11 SOLID WASTE DISPOSAL

In the course of developing and operating the White River Shale Project facilities, relatively small amounts of solid waste (i.e., small compared with the amounts of processed shale) will be generated. These will be disposed of in a landfill operation concurrent or phased with processed shale disposal.

3.3.12 SUPPORT FACILITIES AND REQUIREMENTS

When the White River Shale Project facilities are fully established on Tracts U-a and U-b, the operation will be essentially self-supporting except for the water requirement, which will range from 13,000 to 26,000 acre-feet per year (see Section 7.14) as normal supplies required for operation and maintenance. The project will normally be self-sufficient in electric power and other utilities.

3.3.13 ANCILLARY FACILITIES AND MAINTENANCE

Since this project is being constructed in a relatively remote location, it is necessary that there be available on-tract facilities for repair and maintenance of a wide variety of equipment, for full care of personnel, and for storage and shipment of materials from the plant.

3.3.14 WATER SUPPLY AND FACILITIES

The supply of water required by the White River Shale Project in its various stages will come from the nearby White River. The quantities needed will be purchased from a supply available behind a dam. This dam is proposed by the State of Utah to meet multiple-use needs in the area, including those of the White River Shale Project.

3.3.15 WASTEWATER MANAGEMENT PLAN

White River Shale Project has recognized the very significant value of water in this area and has incorporated all modern techniques for minimum water use as well as wastewater treatment and reuse. There will be no wastewater discharged from this operation to the White River or any receiving stream.

3.3.16 CORRIDOR PLANNING

At this time, the planning of corridors off tract is in a conceptual stage. No firm plans have been completed as to the ultimate destination of the refined shale oil to be produced, nor has the precise source of power lines and water pipelines to serve this area been determined. Contact has been made with appropriate governmental agencies to establish most probable corridors to be used as this project proceeds.

3.3.17 PRODUCT TRANSPORT

In the commercial operation phase of the White River Shale Project (Phases III and IV), the principal product of upgraded shale oil will move by pipeline to refiners for further processing. The most probable plan shows this material moving generally northeast toward the pipeline system that passes through Casper, Wyoming. Generally, it follows established pipeline paths through that territory.

During the earlier single retort operation phase (Phase II), the oil product will move by truck since the small quantity involved makes other transport impractical.

3.3.18 BY-PRODUCT PLAN

During all phases of operation of the White River Shale Project, by-products will be shipped from the plant by truck. These materials include ammonia (which will serve as a marketable fertilizer), sulfur (which may find its way into the fertilizer industry and other applications), and smaller quantities of liquefied petroleum gas (which will serve as fuel). It is anticipated that these by-products will be useful in serving markets reasonably close to northeastern Utah.

3.3.19 CONSTRUCTION PLAN

The plan for construction of an oil shale mining and processing facility at Tracts U-a and U-b includes all field operations necessary for establishing access and moving workers, equipment, and materials into the area; provision of housing and other amenities for workers and their families at the Bonanza area campsite; and the major construction operation at the mining site. Construction operations at the mining site include excavation and preparation of the site for plant construction and the installation of all buildings, equipment, and support structures necessary for the implementation of the commercial development and production plants.

The development program will proceed in four major phases. Each of these phases — initial mine access, single retort operation, and first-train and two-train production — will involve operations at the mining site. These operations have been carefully planned and phased to allow orderly development of the mining facility, minimize construction costs and unnecessary excavations, and avoid adverse environmental effects resulting from construction activities.

Phase I, the initial mining operation, will require 6 months to sink two shafts approximately 1,100 feet deep and a several month mining operation to remove about 30,000 tons of oil shale. Before this operation is started, a short access road will be built between the existing road and the mine to provide access for a small drilling unit and the trucks that will haul loads from the tract for crushing and retorting tests.

During Phase II, the single retort facility will be built, and the access mine will be further developed by enlarging one existing shaft and sinking one new shaft, both some 26 to 28 feet in diameter. This will require a work force of about 200 men and transport of 10,000 tons of materials and equipment to the site. Oil shale removed during expansion of the underground portion of the mine will be stockpiled until the single retort becomes operational. Improvement of roads leading to the site will be necessary before these construction activities can begin.

During Phases III and IV, the commercial production plant will be built, and the mine will be brought to full-scale production by sinking and outfitting, on a phased basis, 12 ventilation shafts and two declines. Oil shale removed for expansion of the underground portion of the mine will be stockpiled until the plant is operational, since Phase II is scheduled to operate 2-1/2 years. The mine will be developed in two phases to coincide with completion of production plant Trains 1 and 2.

Construction of the two 50,000-BPCD process trains and their supporting facilities will constitute the main construction effort of the White River Shale Project program. Consisting of two overlapping phases of 2-1/2 years each and totaling 4 years, this effort will include major earth-moving operations, foundation laying, and equipment installation. It will require a peak work force of about 4,000 manual and nonmanual workers and transport of 350,000 tons of materials and equipment to the construction site.

3.3.20 OPERATIONS MANPOWER

The patterns of development of operations manpower and the levels reached during all phases of the White River Shale Project are presented in conjunction with the discussion of construction manpower.

3.3.21 DECOMMISSIONING-ABANDONMENT PLAN

In the event that the operation on Tracts U-a and U-b is suspended for a period of time, decommissioning provisions will be undertaken. Further, at the exhaustion of shale reserves or because of relinquishment of the lease, abandonment procedures will be instituted. Plans for both of these eventualities have been formulated. The object of these plans is to ensure that during decommissioning-abandonment the leases and the improvements are treated properly and that the environment is protected.

Section 3.4

Section 3.4

LAYOUT OF FACILITIES

3.4.1 GENERAL

The overall layout of WRSP facilities was dictated primarily by the distribution of oil shale in the U-a and U-b sectors and the complex limitations imposed by the rugged terrain.

The primary factors determining the facility layout are:

- Appropriate relative locations for the main plant and support facilities to maximize overall plant efficiency and minimize environmental impact as affected by onsite transit of oil shale and products of the oil shale process plant
- Maximum reuse of facilities throughout all stages of project development
- Ease of access to the site and to the various onsite facilities and equipment
- Appropriate locations for water supplies, runoff collection, and shale disposal areas, dictated largely by the terrain
- Minimization of deleterious effects on the terrain by excavation, construction, and potential floods
- Prevention of pollution due to products and wastes resulting from oil shale processing

The overall site plan and process area plot plan are presented in Figures 3.4-1 through 3.4-4. As shown in Figure 3.4-2, the main process area will be centrally located between the U-a and U-b oil shale centroids. Although potentially more favorable terrain locations are available for the process plant, these locations would require more

extensive and less efficient facilities and equipment for transporting oil shale from remote sections of the mine and processed shale to Southam Canyon, all of which would contribute negatively to environmental problems.

3.4.2 MINE SHAFT LOCATIONS

The vertical access shaft will be sunk in Phase I, the initial mine access phase, and used in Phase II, the single retort operation phase. It will be located for easy access to the secondary crushing facility, the oil shale stockpile, and the processed shale disposal area. This will allow the conveyors and other equipment constructed for oil shale handling during Phase II development to be easily converted and interfaced with the more extensive oil shale handling facilities planned for installation in Phases III and IV, the commercial operation phases. For Phases III and IV, the mine portals will be located to bring the oil shale from the U-a and U-b oil shale centroids to interface directly with the aboveground conveyors for bringing the primary crushed oil shale to the secondary crushing facility.

3.4.3 PROCESSED SHALE DISPOSAL

As shown in Figure 3.4-2, the processed oil shale will be disposed of in the Southam Canyon area immediately adjacent to the main process area. This canyon provides a suitable fill area for the processed shale and a location for a retention dam that will prevent contaminated runoff from entering the White River.

3.4.4 OIL SHALE HANDLING

The raw oil shale will be hauled to the underground primary crushers and then transported to the surface via conveyors in the mine inclines. The most efficient removal of oil shale requires the inclined entries to

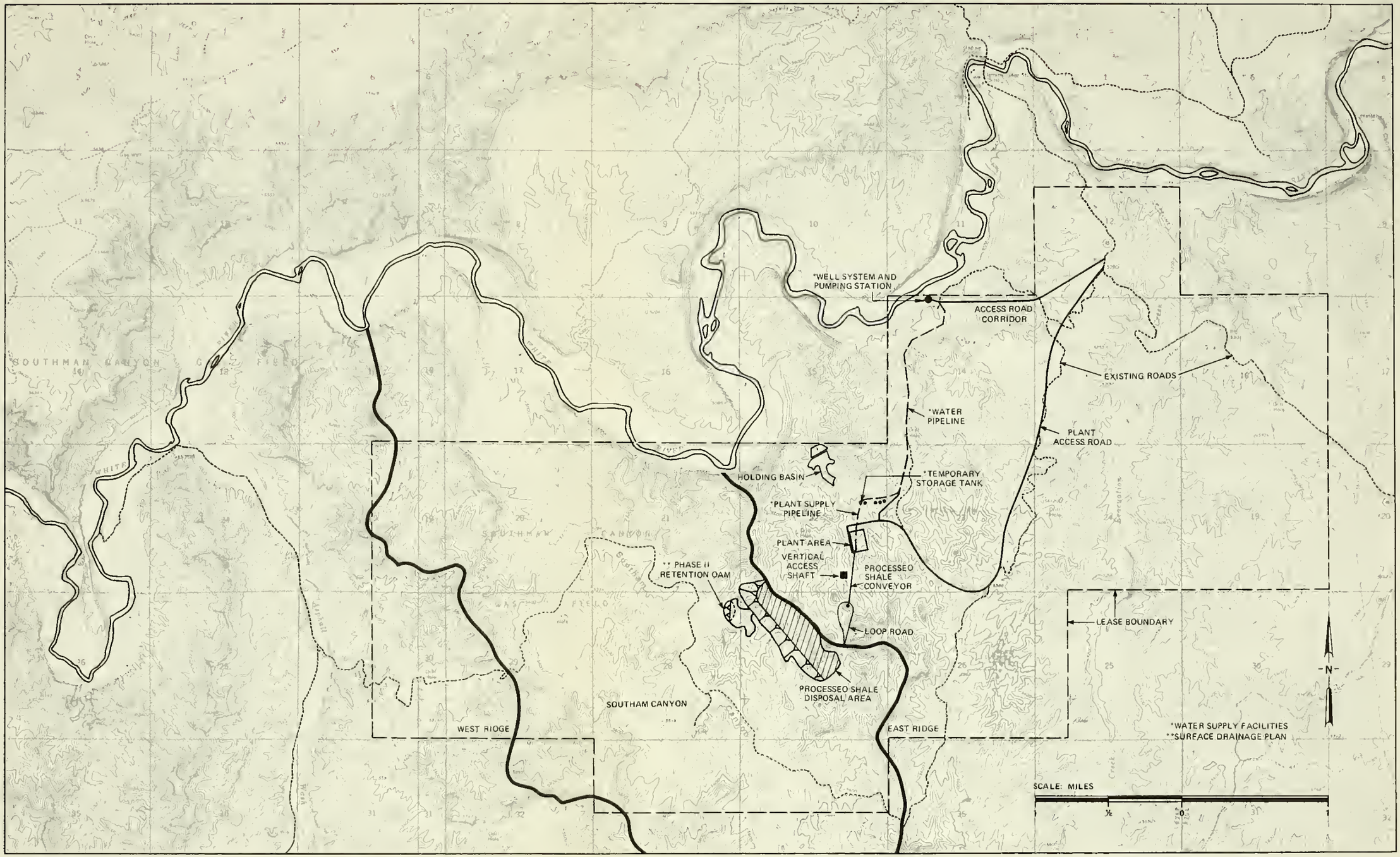


Figure 3.4-1. White River Shale Project Overall Site Plan, Phase II

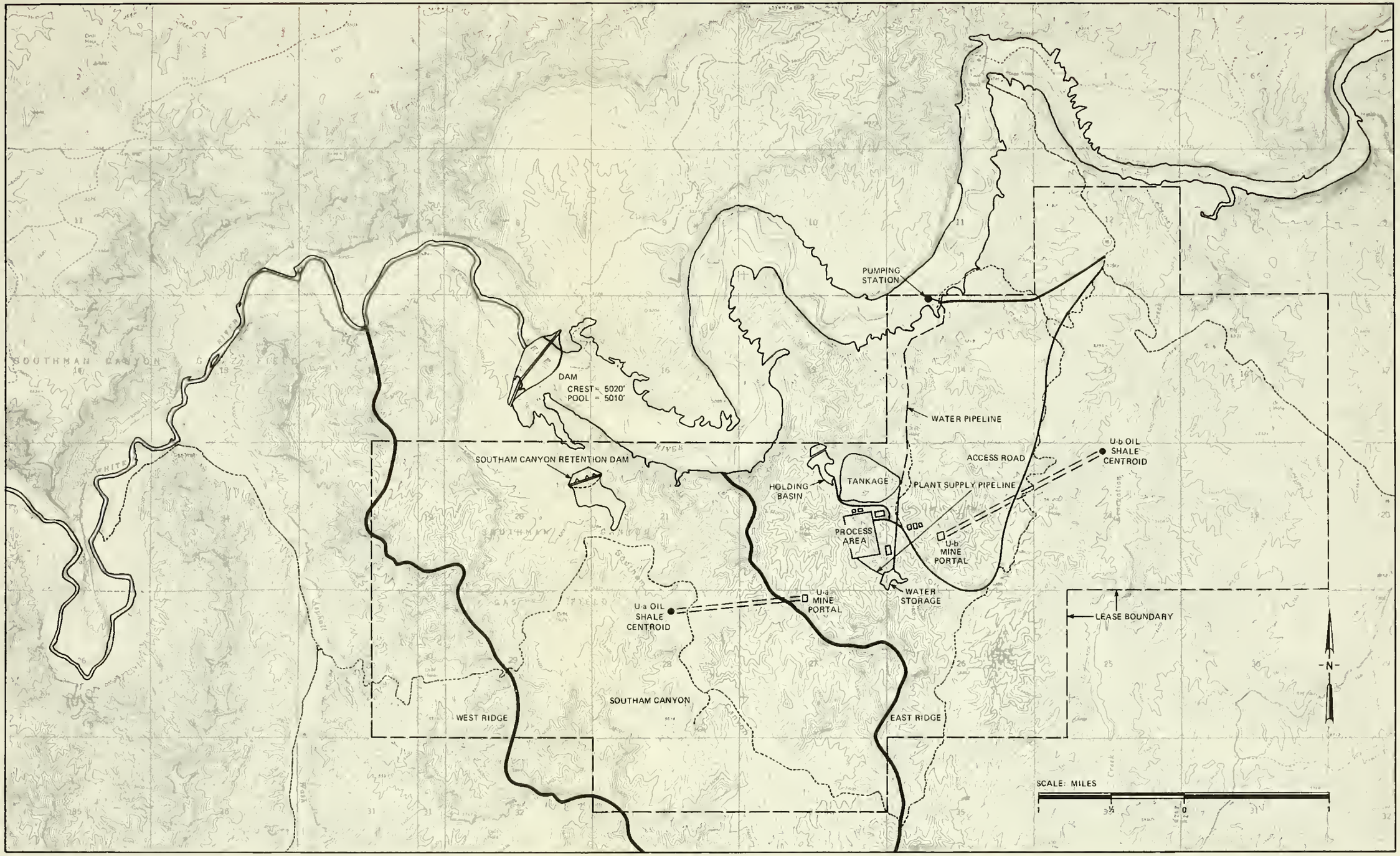
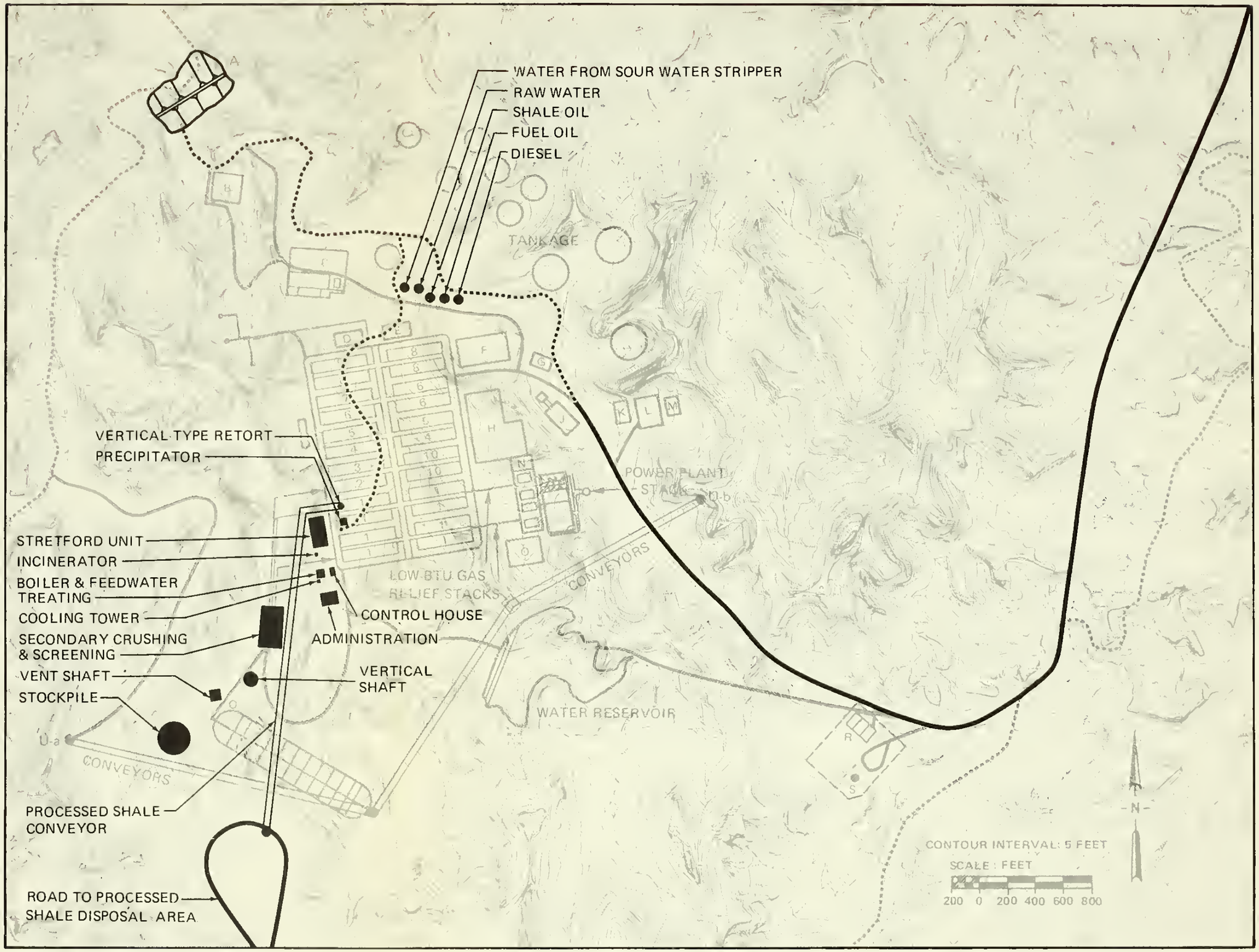


Figure 3.4-2. White River Shale Project Overall Site Plan, Phases III and IV



NOTE: SINGLE RETORT PHASE FACILITY IN SOLID BLACK

Figure 3.4-3. White River Shale Project Process Area Plot Plan, Phase II

LEGEND:

A – TREATED EFFLUENT AND STORM RUNOFF HOLDING POND
B – PRODUCT PIPELINE PUMP STATION
C – WATER TREATING
D – LAB
E – CONTROL HOUSE
F – SHOPS/WAREHOUSE
G – FIRE ENGINE GARAGE
H – SUBSTATION AND SWITCHGEAR
I – MINE ENTRANCE
J — CHANGE HOUSE
K – CAFETERIA
L – ADMINISTRATION PARKING
M – ADMINISTRATION BUILDING
N – BOILER HOUSE
O – AIR COOLING
P – SECONDARY CRUSHING AND SCREENING
Q – PRIMARY CRUSHED SHALE STOCKPILE/STORAGE
R – SULFUR STORAGE
S – AMMONIA STORAGE

1. COARSE SHALE REACTOR
2. FINE SHALE REACTOR
3. COMPRESSOR – HIGH Btu GAS
4. CRUDE SHALE OIL HYDROTREATER UNIT
5. AMINE REGENERATOR
6. HYDROGEN PLANT
7. NAPHTHA HYDROGEN TREATOR UNIT
8. SULFUR PLANT
9. WASTEWATER TREATMENT PLANT
10. COMPRESSOR – LOW Btu GAS

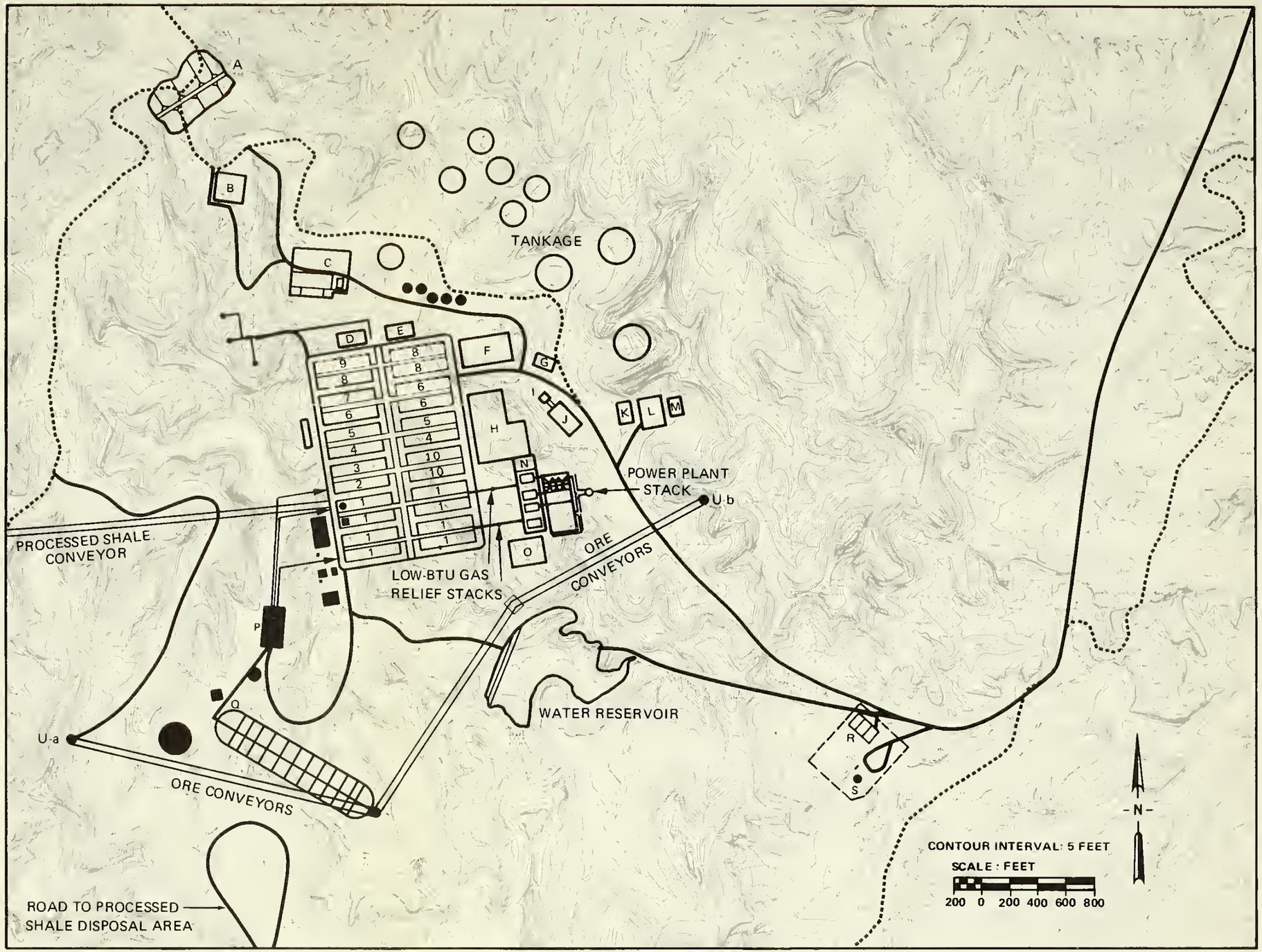


Figure 3.4-4. White River Shale Project Process Area Plot Plan, Phases III and IV

be located at the centroids of the U-a and U-b oil shale deposits. This minimizes truck traffic underground and still allows a small slope for the mine incline conveyor to easily bring the oil shale to the surface.

At the portal, the oil shale will be transferred from the inclined conveyors to the aboveground conveyors. These two aboveground feeder conveyors will intersect with the main conveyor, which will transport the primary crushed shale to the secondary crusher. Another conveyor will take the secondary crushed shale into the process plant. Adjacent to these conveyors will be a stockpile for primary crushed shale. This stockpile will be used in Phase II and in Phases III and IV for buffer storage of shale to balance differences in daily operating rates of the process plant and the mine.

Processed shale will be taken from the process plant on a conveyor to the edge of Southam Canyon for optimal placing in Southam Canyon.

3.4.5 WATER SUPPLY

The pumping station will be built near the bank of the White River, and a pipeline will be laid from the river to the water reservoir. From the reservoir, two pipelines will be laid, one for the process plant and one for the processed shale disposal area. The water reservoir dam will be constructed early in Phase III. The reservoir will be located above the plant to minimize the need for additional pumping. During Phase II, water will be supplied directly to the process plant to eliminate the need for a reservoir.

3.4.6 PROCESS AND SUPPORT FACILITIES

The proposed processing plant will be built slightly north of the midpoint between the two oil shale deposit centroids and oriented to allow shale to

enter the southwest corner of the plant for minimal conveyance, within the constraints of the terrain and the location of other facilities. Since oil products and wastes will exit the north end of the plant, the main oil pipeline, tankage, wastewater collection pond, and waste processing facilities will be situated in this area. This area will be generally downhill from the plant, and the location of the runoff collection ponds will promote flood control and control of contaminated storm runoff and oil spills.

On the east side of the plant will be the maintenance buildings, boiler house, general operation support facilities, and electric power generators. This area will be used heavily for logistics support and will therefore be the best location for the main access road.

3.4.6.1 Single Retort Operation – Phase II

In Phase II, only one retort will be installed for about 5,000 BPCD of crude shale oil. The retort will be constructed at the southwest corner of the main process plant area since the entry of oil shale is at that point. To support this retort, small buildings will be built along the west edge of the future main plant area. These buildings will be converted to other uses in the commercial phase. Additional facilities to be installed in Phase II will include a boiler, electric power generators, waste processing facilities with reduced capacity (for later expansion), five tanks, and the runoff collection ponds. No product pipeline will be required in Phase II since the crude oil product will be trucked out.

3.4.6.2 Commercial Operation – Phases III and IV

During Phases III and IV, Process Trains 1 and 2 will be constructed for 100,000 BPCD of upgraded oil capability, along with all support facilities described above. In addition, an administration complex will be built off the main access road on the east side, near the entrance to the plant.

The main oil pipeline, exiting north from the north end of the plant, will also be installed. Eight additional storage tanks will also be added in this phase.

3.4.7 SITE PREPARATION

Site preparation for surface facilities has been developed to minimize disturbed areas and earthwork in establishing an efficient, functional plan. In general, site work done in Phase II is site work that will be required in later phases.

Most excavated material from the plant site area will be suitable for use as some type of fill in the immediate area. Some excavated material may have to be crushed before being used as structural load-bearing fill. Any high-organic-content material not suitable for fill will be stockpiled for later use in revegetation.

Site work for all drainage impoundment structures will involve removal of weak soils from the area proposed for dam construction. These soils can be used in construction of certain parts of the dam itself. Most of the material for construction of the dam itself will come from the area to be inundated by the stored water.

Construction activities in each stage will disturb only limited areas other than those shown. These other areas will be for material storage and will be located outside temporary work areas.

3.4.8 SITE ACCESS

Because of the rugged terrain and inadequacy of current roads in the area, roads must be improved or built both for plant access and on-tract access to the various facilities. During Phase I, a road will be built from the existing road south to the access mine shaft. In Phase II, the main plant

access roads will be provided, along with on-tract roads branching from the main road to the process plant, water supply pump station, wastewater and storm runoff holding basin, pumping station, and processed shale area. The only additional access required in Phases III and IV will branch from the Phase II access road to the entrance of the U-a mine portal and vent shaft sites. A road will not be required for the U-b mine portal since the existing road will be contiguous with it, but a road will be required for the U-b vent shaft sites.

The main access road will enter the plant on the east side, where most of the logistic support facilities will be located. This road will join existing Highway 45 at a point 0.8 mile south of the White River. From that point, access will be provided by Highway 45, which will be upgraded to Bonanza prior to initiation of Phase II. In addition, a new bridge across the White River will be required in Phases III and IV.

Section 3.5

Section 3.5

MINING

3.5.1 MINE DEVELOPMENT PROGRAM

A commercial oil shale mine will be developed on Tracts U-a and U-b in four phases: an initial mine access phase, a single retort operation phase of up to 10,000 tons per calendar day (TPCD), a first-train operation phase of up to 80,000 TPCD, and a two-train operation phase that will ultimately reach a production rate of up to 160,000 TPCD. Figure 3.5-1 shows a graph of oil shale production versus time. An underground room and pillar mining method has been selected as the most economical and suitable way of extracting the oil shale.

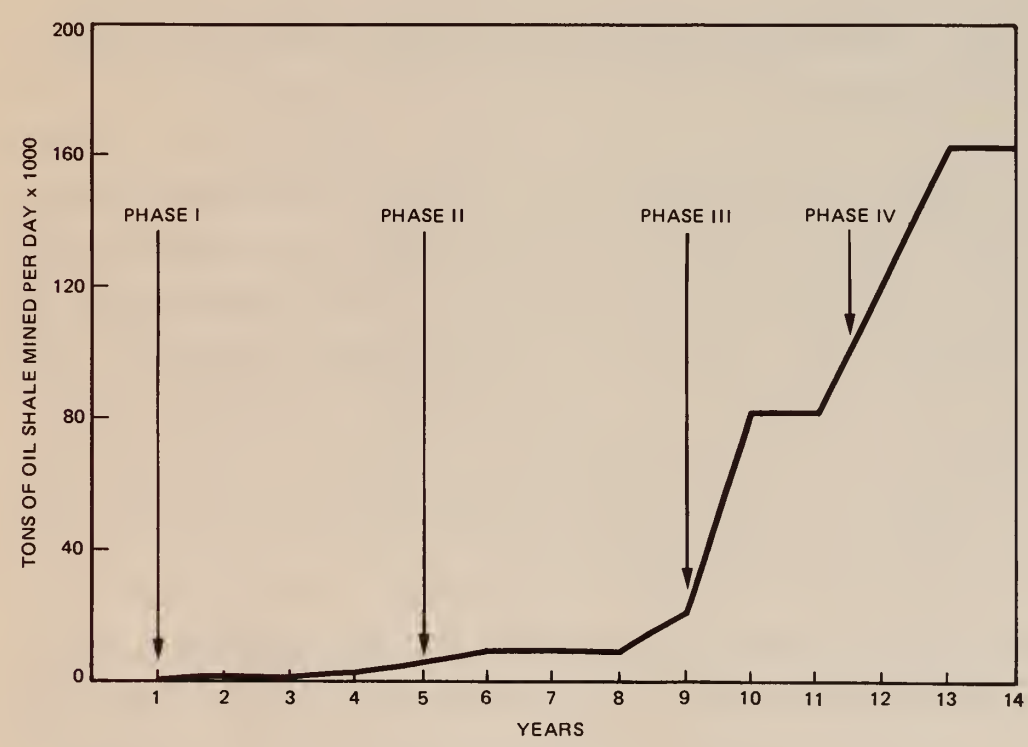


Figure 3.5-1. A Graph of Production vs Time in Process

The geology of the proposed mining zone has been described in three other reports, and so it is not summarized here. For detailed information on the mine geology, refer to "Geophysical Logging Report" (Ref. 75); "Geologic Exploration Program Report" (Ref. 74); and "Preliminary Rock Mechanics Report" (Ref. 71).

3.5.1.1 Initial Mine Access – Phase I

The initial mining activity will include sinking a small access shaft (approximately 6 by 10 feet) about 1,100 feet deep near the proposed Phase II retort site to determine the minability and processability of the shale. Some 30,000 tons of ore will be extracted for retort and crusher evaluation. The access provided by this shaft will also make it possible to conduct vital geotechnical studies to determine roof parting planes, final pillar and mine design parameters, and regional stress data so that the final design can include adequate safety factors. In addition to the access shaft, the program will include a small-diameter ventilation-escape shaft, drifts, and a full-scale 60 by 55 by 120 feet geotechnical test room. This exploration and evaluation phase will require several months to complete.

Upon completion of the two shafts, the underground work will progress on two levels. The upper level will be approximately 35 feet above the lower level. A raise connecting the two levels and a loading trench on the lower level will be completed at this time. When permanent ventilation is established, an inclined drift will be driven upward from the upper level to determine the most suitable parting plane for the mine roof and for geotechnical studies. Drifts beyond the proposed room will be driven with jackleg drills and slusher scrapers.

The upper level of the first room will be driven approximately 20 feet high and will measure 60 feet by 120 feet in plan (see Figures 3.5-2 and 3.5-4). The work will be done with an air-trac drill and a 2-cubic-yard

diesel-powered load-haul-dump unit. The muck will be dumped into the transfer raise which leads to the loading trench on the lower level. The skip will be loaded from the measuring pocket which, in turn, will be filled from the loading trench. Roof bolting will be accomplished with the air-trac, using a smaller, quick change drill. Concurrent with the upper level room development, a horizontal drift for specialized rock mechanics testing will be driven on the lower level. Access to the lower level of the first room will also be driven at this time.

The lower level will be developed by driving a slot raise to the upper level to provide a free face for bench blasting (Figures 3.5-3 and 3.5-4). All subsequent drilling will be in the form of vertical holes from the upper level, using the air-trac drill. The 2-cubic-yard load-haul-dump unit will load and haul the blasted material to to the loading treanch. Ammonium nitrate - fuel oil blasting agents will be used for most of the blasting. All scaling will be done by hand during this phase of the project.

The ventilation system proposed for the project will consist of a main exhaust fan on the surface and a secondary exhaust fan on each level of the underground workings. Fresh air will enter through the access shaft and will be directed to the two working levels through the respective shaft stations. A secondary exhaust fan on each level will be installed at the ventilation shaft and will be connected to rigid 28-inch-diameter fiberglass vent piping leading to the working areas. The ventilation layout is shown on the plan views for the mining levels.

The main fan will be driven by a 50 horsepower motor and will be reversible. This fan will produce 30,000 cubic feet per minute (cfm) at 11 inches water gauge. This fan will be offset from the shaft and will be equipped with all required control and alarm features. Secondary fans, rated at 15,000 cfm each, will be driven by 25 horsepower motors.

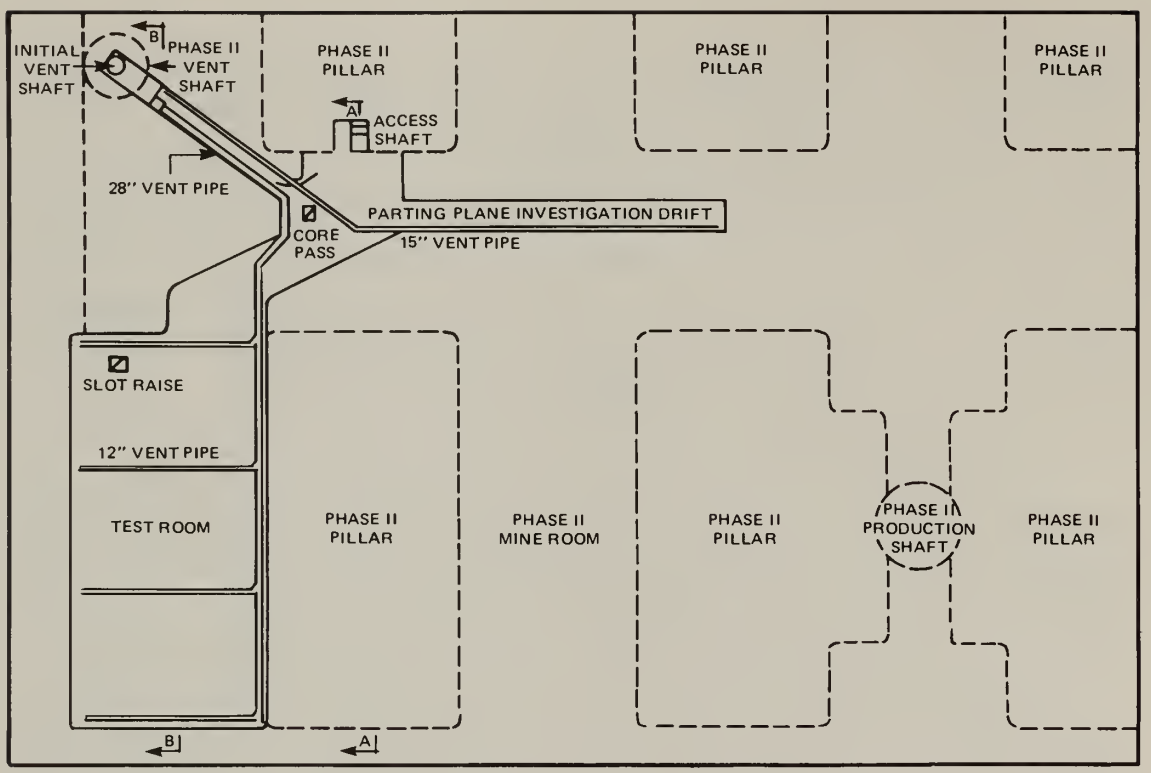


Figure 3.5-2. Phase I Upper Level Mine Layout

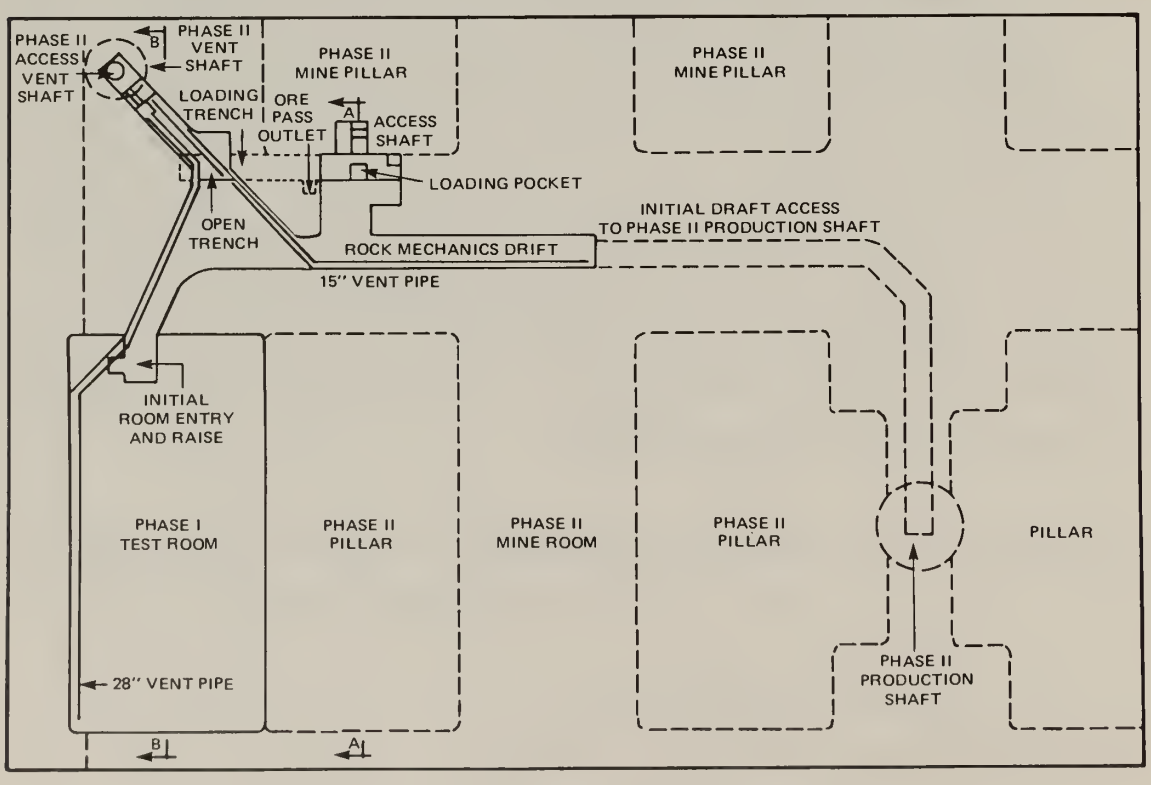


Figure 3.5-3. Phase I Lower Level Mine Layout

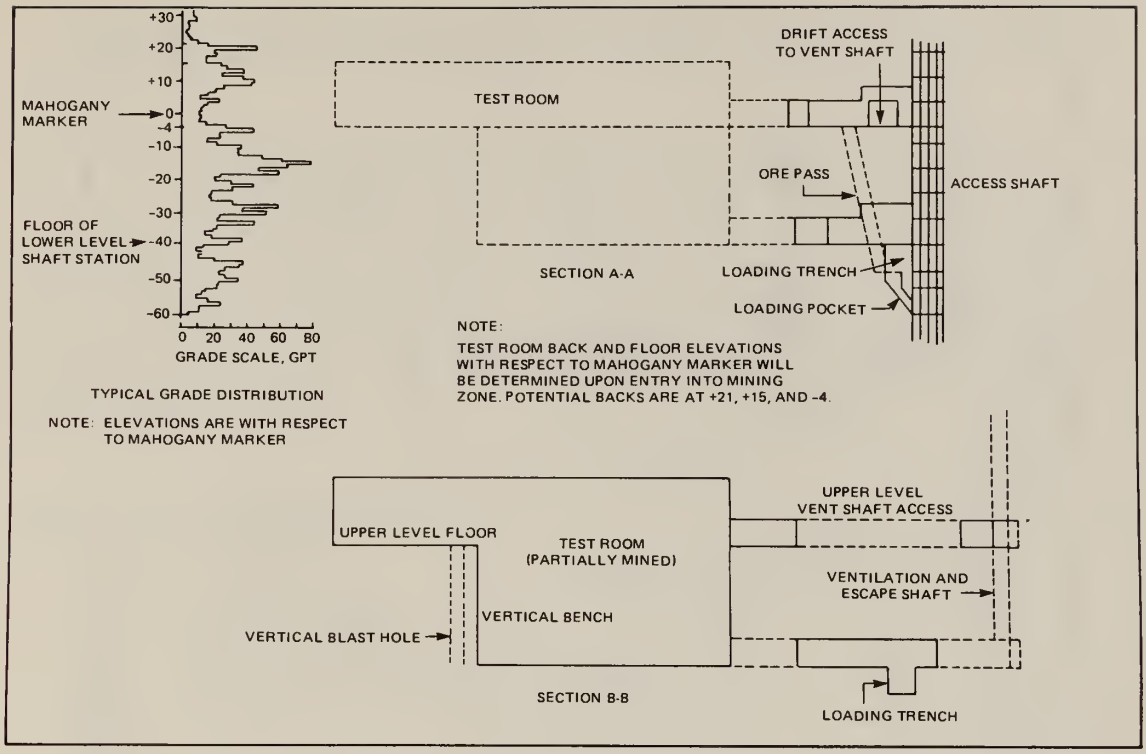


Figure 3.5-4. Phase I Mine Plan Cross Section

A continuous, recording combustible gas monitoring system is planned so that any possible gaseous emissions from the mining zone can be monitored.

Figure 3.5-5 shows the Phase I surface facilities.

3.5.1.2 Single Retort Operation – Phase II

The goal of the single retort operation phase is to bring into production a mine capable of providing up to 10,000 TPCD of oil shale. A production shaft about 25 to 30 feet in diameter will be sunk in the vicinity of the initial access shaft. The access shaft, hoist, and headframe will remain

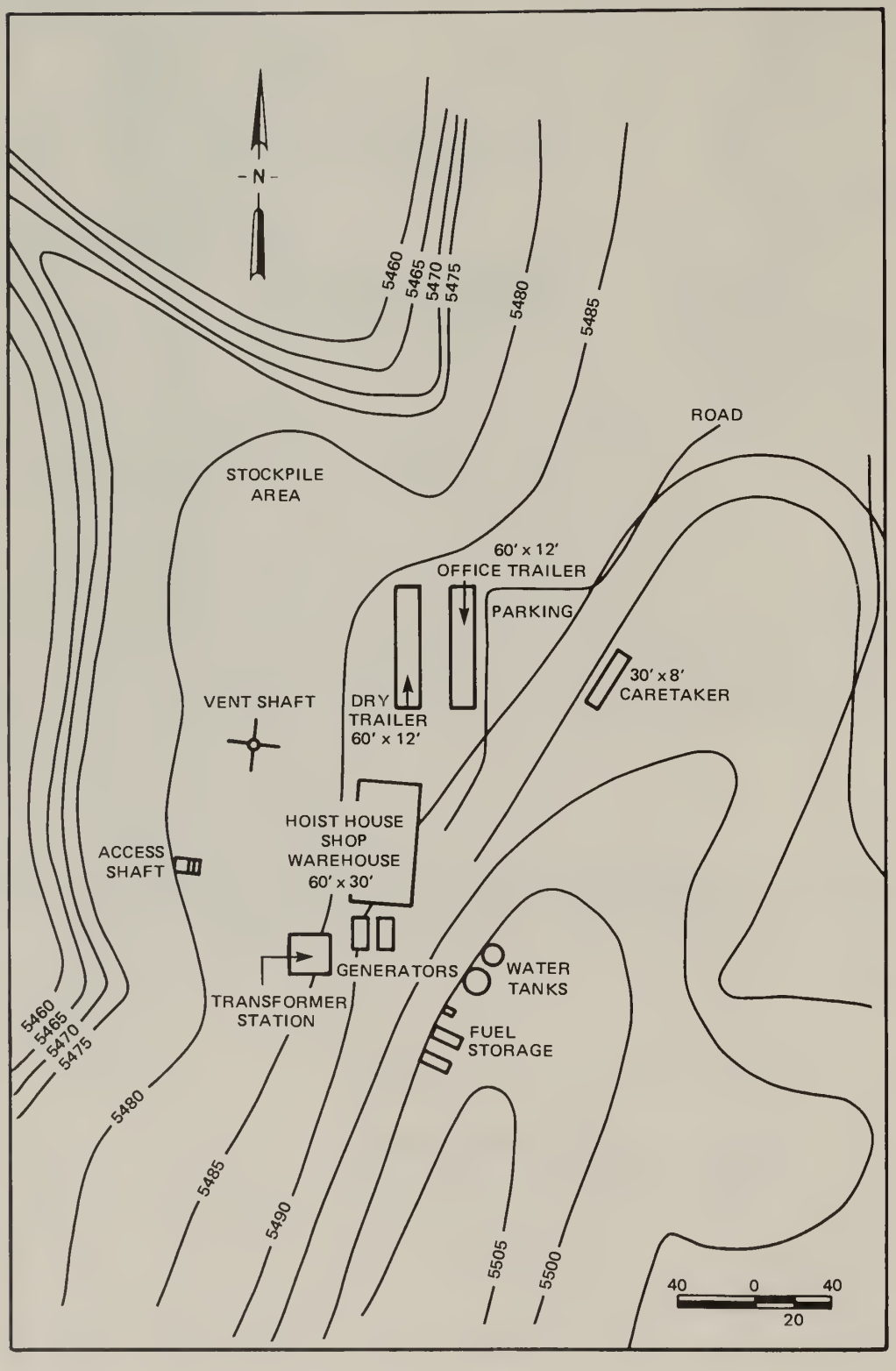


Figure 3.5-5. Phase I Surface Facilities

as a service-escape shaft, and the initial ventilation-escape shaft will be enlarged for use as an upcast ventilation shaft.

The proposed hoisting system will be driven by a headframe-mounted friction winder powered by large electric motors. The production shaft will contain two 14-ton-payload skips in balance and one counterbalanced man and materials cage capable of handling infrequent loads up to 28 tons. Skip loading will be by automatic measuring pockets, and the skip cycle time will be 66 seconds.

Cycle breakdown is as follows:

Load	15 seconds
Accelerate	11 seconds
Constant velocity	24 seconds
Decelerate	11 seconds
Creep	5 seconds
Total	66 seconds

This shaft will also serve as the main ventilation air intake. Shaft diameter is dictated by underground equipment dimensions. A second shaft, about 20 feet in diameter, will serve as the exhaust air course. The 20-foot shaft size is dictated by ventilation requirements.

Underground development will consist of driving entries to the mining panel area, and to shop, warehouse, primary crushing, and ore handling facilities. In addition, all associated facilities, including ventilation and utilities distribution, will be completed. Initial mine development will proceed in an easterly direction.

Surface construction will include headframe and hoisting facilities, fan installation, a change house, an office, and a parking lot. All surface shaft and production areas will be adequately fenced to protect the facilities and humans and animals in the area.

These developmental activities will begin some 8 months before the end of the access shaft project and will take 3 years to complete, culminating in a sustained mine production rate of up to 10,000 TPCD for an additional 2-1/2 years. Panels will be developed and mined east of the shaft locations during this phase. Figure 3.5-6 shows the shaft and panel layout for the 10,000 TPCD operation.

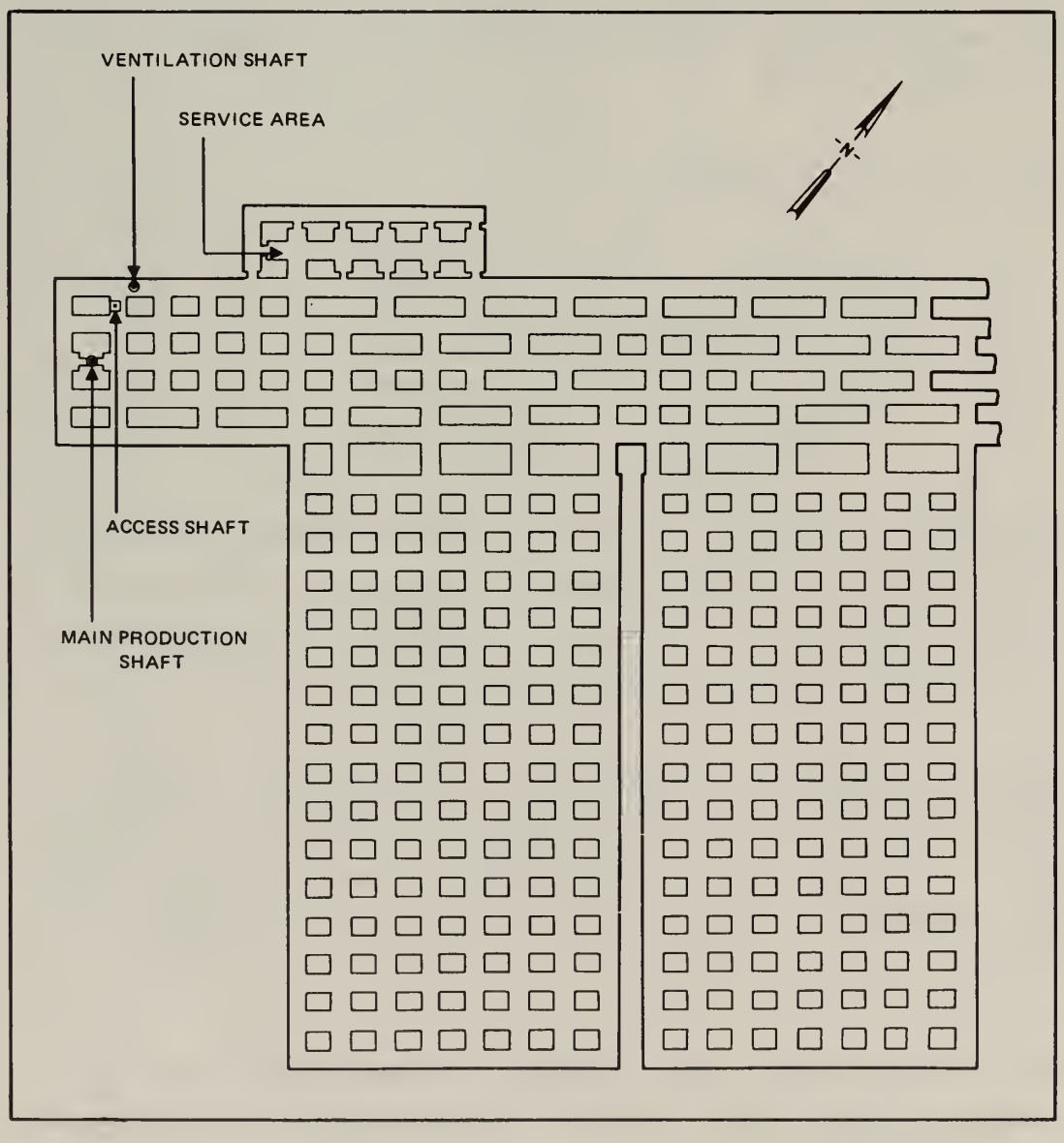


Figure 3.5-6. Shaft and Panel Layout for Phase II

3.5.1.3 First-Train Operation – Phase III

First-train operation refers to a production rate up to 80,000 TPCD. Development to reach this level of production will continue northeast toward the centroid of Tract U-b. The present plan is to drive an inclined entry from the surface near the retort site to the mining zone and from there to the U-b centroid to act as a beltway for removing ore from the mine. The Phase II production shaft will serve as the man-and-material shaft. Depending on ultimate ventilation requirements, a maximum of up to six ventilation shafts will be sunk in the centroid area to provide up to 6,000,000 cfm of additional air for the expanded operation. Additional underground shop and warehouse facilities will be constructed near the centroid of Tract U-b to serve as the central shop area for subsequent expansion. Minor maintenance will be done at temporary shops near the working panels. Surface structures will be located to fit into the surface topography as well as to fit the pattern of underground workings.

Panel mining will radiate from the centroid, and mining will proceed concurrently within four panels. At any given time, each of the four panels will be assigned a separate phase of the mining operation. One panel will be assigned to drilling, one to charging and blasting, the third to loading and hauling, and the fourth to scaling and roof bolting. The assignments will rotate as the mining functions are completed. The ore produced will pass through a primary crusher before being conveyed to the surface for secondary crushing and retorting.

The development stage of first train operations will last approximately 3 years. Development ore will feed the commercial stage retorts, and the surplus will be stockpiled.

3.5.1.4 Two-Train Operation – Phase IV

The two-train operating phase will increase the production rate to an ultimate 160,000 TPCD. An inclined beltway will be driven from the retort

area to the mining zone and from there to the centroid of Tract U-a. As in the first-train operation, up to six shafts will be sunk outside the Southam Canyon drainage system to allow delivery of as much as 6,000,000 additional cfm of ventilating air to the mine. These shafts will not be near the centroid, which lies in Southam Canyon, because that area will be used for processed shale disposal. The Phase II production shaft will be converted to a man-and-materials service shaft. The general mine layout is shown in Figure 3.5-7.

All mining activity will follow the same pattern as the first-train operating phase. Production is projected to continue at this rate until the reserves are depleted.

3.5.2 MINE DESCRIPTION

The following paragraphs describe the surface and underground facilities, means of access, the primary mining functions, and optional haulage systems.

3.5.2.1 Surface Effects and Facilities

The surface effects of developing the mine will be limited to the required shafts and their ancillary structures for hoisting and ventilation, access roads, change house, and office facilities. The explosives magazine will be built in a safe location in accordance with existing state and federal regulations. Most of the mine maintenance facilities will be underground. Proper design of the support pillars left intact in the room and pillar mining method will ensure that surface subsidence is insignificant. Material from shaft sinking will be stockpiled and used for grading around the surface facilities. The location of surface facilities is shown in Figure 3.5-8.

Figure 3.5-7. General Mine Layout

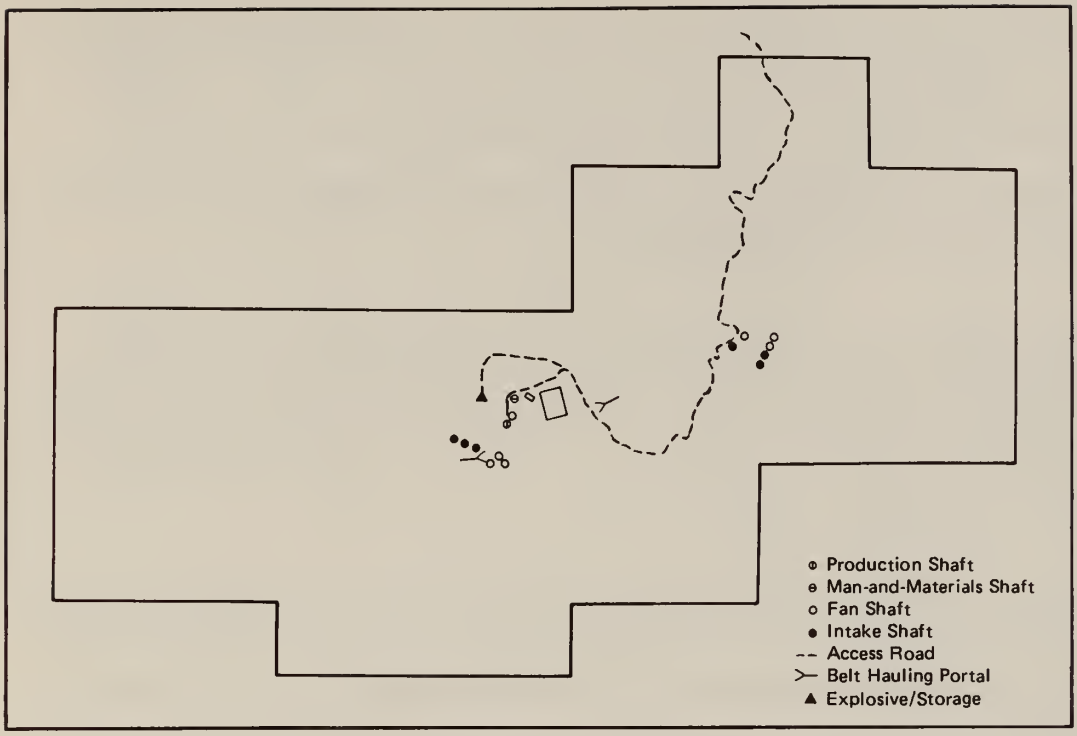


Figure 3.5.-8. Layout of Surface Facilities – Mining

3.5.2.2 Shafts and Ventilation System

Vertical shafts will provide access to the mining zone in the initial phases of operation. These shafts will be located in accordance with underground requirements.

In the initial phases, all men, materials, and ore will be hoisted. The production and service shafts, along with other intake shafts, will also serve as air intake shafts, as required. Exhaust shafts with surface mounted fans will be part of the ventilation system. The ventilation shafts will be circular and may be lined, with diameters consistent with ventilation requirements. The man-and-materials shaft will be large enough to allow lowering the mining equipment into the mine without cutting basic components. An exhaust ventilation system of the type used

in a typical coal mine room and pillar layout is planned. The air will be drawn down the intake shafts; delivered to the working areas by the use of stoppings, overcasts and undercasts, brattice lines, regulators, and other structures as required by the large openings; and exhausted through vertical shafts by fans mounted on the surface. Auxiliary fans may be used in the working areas.

Each working district will have its own fresh air supply in quantities sufficient to meet all statutory requirements for air quality and velocity. Abandoned areas may be sealed or ventilated by a bleeder system, depending on the final use of the area.

Fans will be offset from the shafts and will be provided with explosion doors and all other required safety and alarm features. Underground structures will be nonflammable and will be designed to direct the air effectively to the working areas. Air quality and quantity will be continuously monitored. A typical ventilation system for a panel is illustrated in Figure 3.5-9.

3.5.2.3 Mining and Work Plan

A two-bench room and pillar system is proposed as the most appropriate mining method. The upper bench will be 35 feet high, while the lower bench height will vary depending on the thickness of the total mining zone. A typical configuration is shown in Figure 3.5-10. The mine will be divided into panels consisting of eight rooms and 15 or more crosscuts. The panels will be separated by barrier pillars to provide for ventilation and roof support.

All mine development will be on the upper level, with the exception of return air courses, which will be driven full height. Lower benches in the panels will be developed with ramps from the entry system. The mining height will vary from 40 to 70 feet, with 55 feet being the most

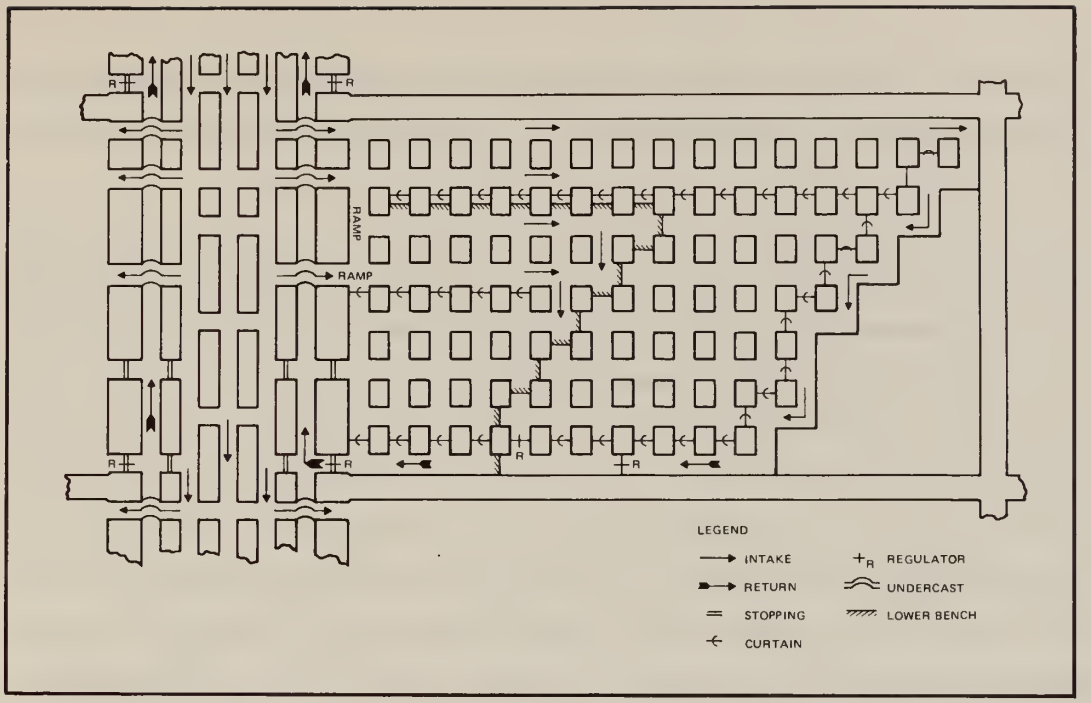


Figure 3.5-9. Typical Ventilation System in a Mining Panel

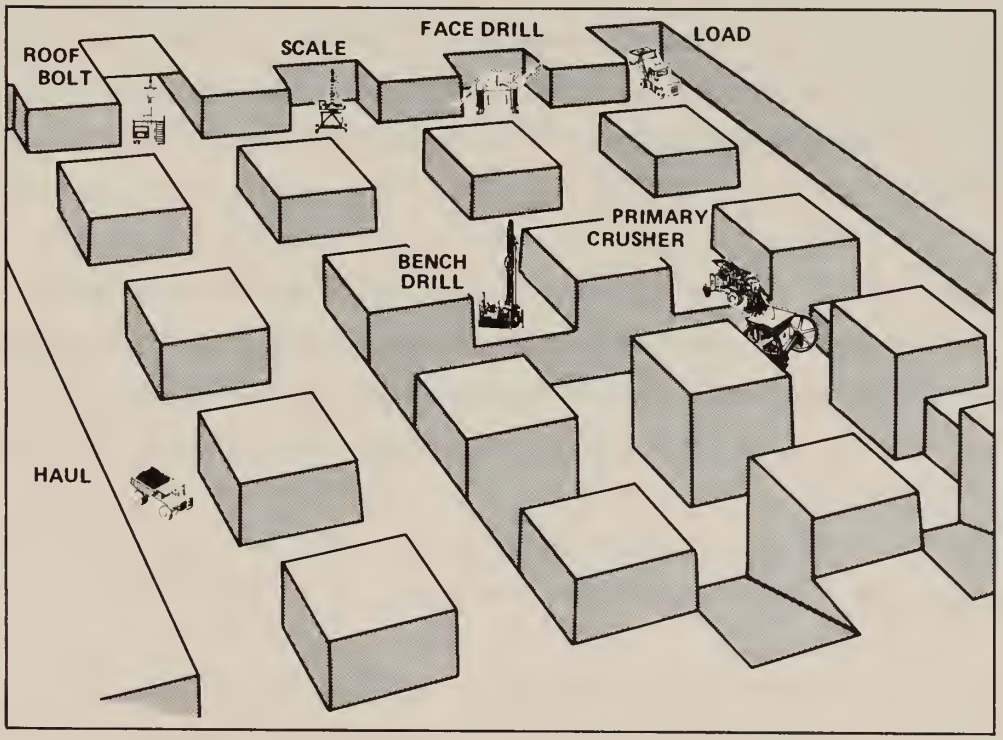


Figure 3.5-10. Two-Bench Room and Pillar Mining Scheme

common. A five-entry system will provide access to the mining panels. Three of the entries will provide air intake, haulage, and service activities; the remaining two will serve as return air courses.

On the basis of preliminary rock mechanics test work using a 2.5 safety factor, rooms and crosscuts 60 feet wide and entries 50 to 55 feet wide are planned. Pillar dimensions within the panels will be 60 to 80 feet. Entry pillars will be 60 feet wide, and their length will be determined by panel access requirements and the statutory maximum distance between crosscuts. The dimension has not yet been defined. Initial panel mining will be on the upper level and will proceed approximately 400 feet before lower level mining begins. The distance of 400 feet will be maintained throughout the operation. Rock mechanics studies indicate that resource recovery will be nearly 70 percent of the defined mining horizon. For full details on the rock mechanics investigation, refer to the "Preliminary Rock Mechanics Report" (Ref. 71).

Conventional drilling, blasting, loading and hauling, scaling, and roof bolting techniques will be employed in the proposed mining plan. Specialized equipment, scaled up to fit the large-sized openings, will be required.

Drilling. Upper level drilling will be accomplished with specialized drill jumbos capable of drilling 4-inch-diameter or larger horizontal holes up to 30 feet deep. The drill units will be self-contained, with compressed air, drill water tank, and hydraulic system power supplied by a diesel engine. Diesel exhaust will be conditioned to reduce emissions of noxious gases to an acceptable level. The drill operators will work in enclosed, air-conditioned, acoustically insulated cabs.

Lower level drilling will be accomplished by vertical drills capable of drilling 4-inch-diameter or greater holes to a depth of 20 feet in a single

pass and possessing the ability to add steel for greater depth, if needed. The drills will be self-contained, with all the features of the face jumbos.

Charging and Blasting. An ammonium nitrate - fuel oil based blasting agent will be placed pneumatically in the horizontal and vertical drill holes. All explosives and detonation devices will conform to statutory requirements, which are not yet completely defined. The charging carriers will be self-contained and will transport sufficient explosives for one shift.

Each hole will be primed with a high-strength primer that contains a cap and delay element. Cap initiation is by low-energy detonating cord. The detonating cord for all holes is connected together and initiated by a single cap and fuse. This system provides economic and safety advantages over electric cap initiation.

Loading and Hauling. The blasted material will be loaded into conventional haul trucks with diesel-powered, front-end loaders or into load-haul-dump units, and hauled to a dumping point. In all cases, the equipment will have exhaust conditioners and air-conditioned and acoustically insulated cabs with adequate protection against rollover and falling objects. The haulage system is discussed in greater detail in Subsection 3.5.2.4.

Scaling. Loose rock will be removed from the roof, ribs, and face with a mechanical scaler capable of reaching all potentially loose material while allowing the operator to remain in a safe location.

Roof Bolting. A systematic pattern of roof bolts will be used to support the exposed roof as required to ensure the safety of mining personnel. It is presently proposed that bolts be installed on approximately 6-foot centers. Both mechanical and resin-type bolts will be employed as conditions dictate. The roof-bolting machine will use drills mounted on elevating

platforms. As experience is gained with equipment of this scale, the degree of sophistication in machine design will increase. Roof bolters and all of the underground equipment will be self-contained.

Support Activities. All support equipment and vehicles will be diesel powered with exhaust conditioners. Maintenance and warehousing facilities will be centrally located underground.

3.5.2.4 Haulage System

Initially, the blasted material will be hauled to a central crusher site in conventional diesel haulage trucks. Two entries will be devoted to production haulage and will be well lighted, with one-way traffic for safety and efficiency. Alternative methods that may be used subsequently are described in Subsection 7.5.4. Phase II operation includes conveyor belts from the crusher station to the production shaft where crushed material will be hoisted to the surface. Phases III and IV will probably include conveyor belts and machines to transport the crushed material to the surface.

3.5.2.5 Dewatering System

Present information indicates that mine drainage will not be a problem in the mine. Water encountered will be pumped to strategically located underground storage facilities and used for dust suppression in the mining operation. If the amounts encountered exceed the mining requirements, large underground storage pits will be excavated, and pumping facilities will be installed. Water pumped from the mine will be discharged into the wastewater holding pond, as described in Section 3.15.

3.5.2.6 Mine Utilities

Utilities required for the mining operation are shown in Table 3.5-1 for mining rates of 10,000 TPCD and 160,000 TPCD.

Table 3.5-1

MINING OPERATION UTILITY REQUIREMENTS

	10,000 TPCD	160,000 TPCD
Potable water (acre-ft/yr)	3	43
Nonpotable water (acre-ft/yr)	56	1,100
Electricity (kW)	5,000	30,000

Nonpotable water for dust and fire control will come from mine drainage and from the wastewater holding pond. It may be necessary to bring some additional water from the surface. Potable water will be piped into the mine and distributed to points accessible to the work force.

Chemical toilets will be used in the mine, and ensuing wastes will be disposed of in the surface sewage facility. Trash will be collected systematically and transported to the surface for disposal.

Electricity will be supplied at 13.2 kilovolts to the fans and underground areas by power cable routed down either the production shaft or a separate bore hole.

In an effort to minimize potential fire hazards, underground diesel fuel storage will be limited to the volume carried in the supply trucks. An aboveground metering system will limit the amount of diesel fuel piped into the mine at one time to the capacity of one supply truck.

A telephone system will be installed for intramine and mine-to-surface communication. A low-frequency-radio emergency backup system will be provided.

3.5.3 MINE SAFETY

The mine and ancillary facilities will be designed, constructed, and operated in accordance with the State of Utah Metal and Nonmetal Health and Safety Standards and with the Federal Metal and Nonmetallic Mine Safety Act.

A comprehensive program of safety indoctrination, training, and retraining will be an integral part of the mine operating plan. Planned safety contacts on an individual and group basis will supplement the regular safety meetings and random contacts that are common to most safety programs.

Mining personnel will be trained in underground evacuation and survival. Alternative escape shafts are planned, and travel ways will be maintained and posted for emergency use. An emergency warning system will be installed that may be any one or a combination of audible, visual, or olfactory alarms. Self-rescuers will be mandatory for all people going underground. Provision of mine rescue apparatus and training is also part of the overall safety program.

All equipment will be supplied with the devices needed to provide a safe working environment for the operators, and the maintenance program will be designed to keep all equipment in safe operating condition. Protection against rollover and falling objects will be furnished where applicable, self-contained fire extinguishing systems will complement the standard portable extinguishers, and lockout and barricading programs will be enforced.

A fire prevention program for the underground mine area will center on training and proper housekeeping. All workers will be trained to recognize potential fire hazards and to correct them. Trash will not be allowed to accumulate, but will be systematically removed from the mine and disposed of at the proper surface facility. Equipment will be properly maintained to reduce the chance of fire. Flammable commodities will be

stored only in limited quantities and in fire-resistant structures; diesel fuel will be stored on the surface.

Major units will be equipped with self-contained fire extinguisher systems, and portable fire extinguishers will be placed at strategic locations. All water trucks will have hoses and nozzles for fire fighting, and a foam-type fire truck may be included in the program. All workers will be trained in fire fighting techniques.

Roof bolts will furnish the primary roof support, and the rooms and pillars will be designed to keep spans within the limits of the roof strength. A continuing program of inspection and testing will ensure good roof conditions. Periodic scaling of the ribs in active workings will remove loose rock, and mined-out areas will be sealed or barricaded and posted against entry.

Blasting agents will be brought into the mine in bulk. Underground magazines will be used for boosters, detonators, and blasting agents, and will conform to all state and federal regulations.

3.5.4 VEGETATION REMOVAL PROGRAM

The surface facilities for mine support will be generally small and scattered and will disturb only approximately 50 acres of the 10,240-acre lease area. Vegetation is sparse and soil cover thin on the upland areas selected. Topsoil will be graded into the existing terrain or used as deemed appropriate.

3.5.5 MINE WASTEWATER CONTROL

Mine drainage is expected to occur in small amounts and to be of a quality acceptable for dust suppression and other uses within the mine, thus proportionally reducing freshwater (or treated wastewater) requirements. If enough mine drainage occurs to require pumping from the mine area, it will be disposed of by the methods discussed in Subsection 3.5.2.5.

3.5.6 MINE AIR EMISSION CONTROL

The mining operations of drilling, blasting, scaling, loading, transferring, and unloading will generate air pollutants. Particulates will result from all basic mining activities, and gaseous pollutants will be created by blasting and underground use of diesel engines. Diesel engine combustion products and blasting fumes, along with minor amounts of methane, welding fumes, and dust, will compose the principal emissions from the mine. However, effective measures will limit the accumulation and emission of pollutants to the atmosphere (see Section 4.2).

The following control measure will be employed to minimize dust:

- During drilling, water and wetting agents will be applied at the drill bit to control dust.
- Muck piles of blasted shale may be wetted before loading to minimize dust generation. Wetting agents may be used if they prove effective in reducing water requirements or in improving dust control.
- Truck haulage routes will be maintained using conventional road wetting and chemical stabilization techniques.

The principal gaseous air pollutants resulting from diesel engine exhaust and from blasting will be carbon monoxide, nitrogen oxides, and hydrocarbons. Diesel engine combustion products will pass through a catalytic converter or a wet scrubber before entering the mine atmosphere. The engines and converters or scrubbers will be maintained regularly as the most positive means of limiting emissions.

If diesel fuel for underground equipment is produced from the shale oil, it should generate less smoke and sulfur dioxide than industry standard No. 2 diesel fuel. All diesel engines will be equipped to meet federal air emission standards for underground operation. Where feasible, mining equipment cabs will be air conditioned to protect the operators.

The mine ventilation system will remove blast fumes and dust from working panels as quickly as possible by immediately directing it into the exhaust air system. Because of the large openings and low ventilating current velocities, dust probably will not be transported over long distances in the return air courses, but will settle out. If more effective measures are required, additional water sprays will be installed near the bottom of the upcast shafts, or ventilation air will be passed through mined-out panels.

Dust and fumes caused by blasting will be diluted and effectively removed from work areas by fresh air from the mine ventilation system. Fumes will be minimized by selecting a blasting agent compatible with hole conditions (wet or dry) encountered while drilling.

Estimated emission rates of air pollutants and their effects on ambient air quality are discussed in Sections 4.2 and 5.2.

3.5.7 MINE NOISE CONTROL

A method of noise control will be required in the underground mine. Equipment design will include the latest technological advances in sound suppression as well as additional operator protection in the form of insulated cabs wherever possible. To further lessen noise intensity, the number of machines working in a given area will be controlled. In addition, a room and pillar configuration will aid in reducing line-of-sight noise propagation from one working area to another. Other underground noise sources will be neutralized by isolating affected personnel or by using individual ear protection devices. Normally, blasting will take place during shift changes to minimize exposure to that source of noise. The blasting crew itself will be protected by a combination of distance from the blast and the use of ear protection devices.

Because of the variable nature of their work, personnel engaged in support activities will be subjected to differing noise levels. Most of these activities, however, will be carried out in areas where equipment noise will not be excessive. Individual ear protection will be provided where required. In some instances, it may be necessary to reduce noise exposure time.

Ventilating fans will be the principal source of noise on the surface, but these will be located so as to minimize impacts on workers and fauna habitats.

Section 3.6

Section 3.6

FEED PREPARATION AND TRANSPORTATION

The process of readying the mined oil shale for retorting will require facilities for crushing, screening, storing raw shale, and feeding the retorts. There will be two stages of crushing operations before retorting: primary crushing and secondary crushing. Primary crushing, the first step in the preparation of the oil shale feed will take place in stations located underground at the mining level; secondary crushing will take place on the surface, near the retorts. The type of retort used will determine the size to which the oil shale must be crushed. Covered conveyors will transport oil shale to crushers, the stockpile area, bins, retort feed hoppers, and finally, will move the processed shale to bin load-out points for final truck disposal. A process flow diagram is shown in Figure 3.6-1.

Primary crushed oil shale will be stockpiled at a location between the primary crusher and secondary crushing plant to ensure uninterrupted operation of the secondary crusher and continuous feed to the retorts. The mine haulage system and primary crushing operations will be interdependent. If the primary crusher is shut down, haulage from the mine will be stopped; the secondary crusher will then be fed from the stockpile.

3.6.1 FEED SPECIFICATION

The oil shale will be broken into pieces smaller than 10 inches, a size suitable for traveling on the conveyor belts, in the primary crushing step underground. At the surface, secondary crushing steps will reduce these pieces to appropriate sizes for retorting. Coarse-shale, vertical-type

retorts could require feed material between 1/2 inch and 3 inches; fine-shale, fines-type retorts can be used to process the fines smaller than 1/2 inch. The operations that will produce such a suitable feed are described in the following paragraphs.

3.6.2 SINGLE RETORT OPERATION – PHASE II

The single retort operation phase refers to an operation that mines and crushes enough oil shale to feed one full-scale vertical-type coarse-shale retort – approximately 10,000 tons per calendar day (TPCD). All equipment will be electrically powered.

3.6.2.1 Primary Crushing

The primary crushing station for the single retort operation phase will be located underground at the mine level. The crushing facility will consist of one unit. The total nominal crushing rate will be 8,700 TPCD, but the facility will be designed to allow for 15 percent increase in capacity to 10,000 TPCD.

A roll crusher is proposed for primary crushing to suit the capacity and product size requirements of the plant. Roll crushing is recommended because it creates less fines and dust with this particular material than do other methods available.

Haulage units will dump into a grizzly, where plus 42-inch material will be separated for secondary breakage by a hydraulic impact tool. A 250-ton hopper below the grizzly will recive the minus 42-inch feed. A large pan feeder under the hopper will supply a 48- by 72-inch McClanahan-type toothed single roll crusher, which will reduce run-of-mine rock to a minus 10-inch primary product. A conveyor belt under each crusher will transport the product to a common belt, which will discharge into a 700-ton surge pocket immediately ahead of the skip loading installation.

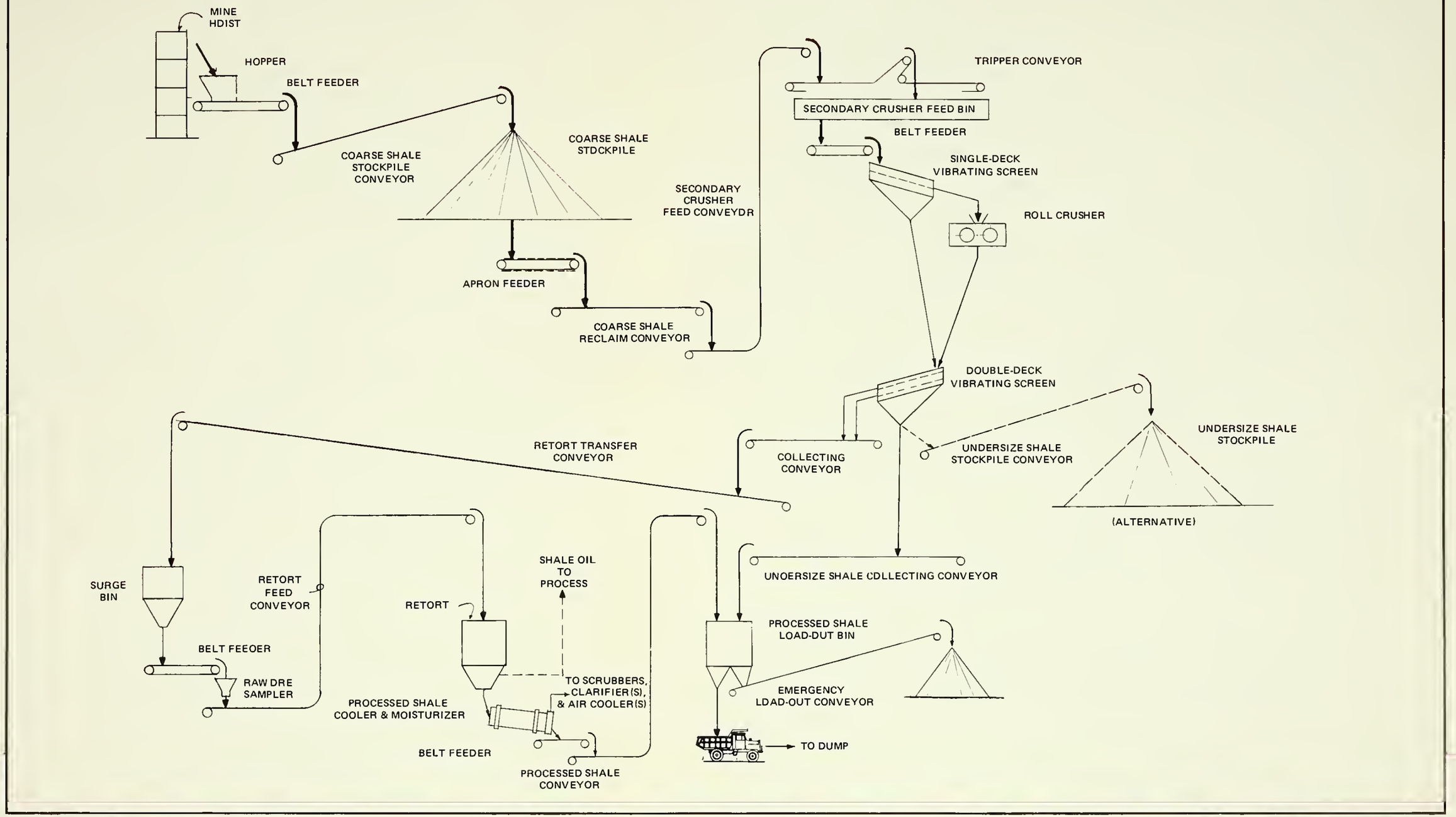


Figure 3.6-1. White River Shale Project Material Handling Diagram, Phase II

The primary crushing structure will house the apron feeders, monorail crane (needed for maintenance), control room, and servicing facilities. Auxiliary equipment will include dust suppression and collection systems and a ventilating fan and air conditioner for the control room.

The minus 10-inch crushed product will be transported by a mine hoist through a vertical shaft to a storage bin at the surface. A belt conveyor fed by a belt feeder from the storage bin will discharge coarse shale onto a conical stockpile.

3.6.2.2 Stockpile

The primary crushed product will be conveyed to a conical stockpile located near the secondary crushing plant. This raw oil shale stockpile will be in the open and of an appropriate size to support single retort operation for several days (the present estimate is approximately 75,000 tons). Water sprays and/or mechanical systems will suppress dust during the stockpiling operation.

Oil shale will be drawn from the stockpile by apron feeders onto a belt conveyor through a reclaim tunnel. A dust collection system will be provided at the reclaim tunnel. This system is discussed in Part 4.

3.6.2.3 Secondary Crushing

Primary crushed shale will be reduced in two lines of secondary crushers and screens. Each final crushing facility will have a nominal crushing rate of 370 tons per hour and will operate on a 24-hour-per-day, 365-day-per-year schedule. Each operating line will meet the full requirement of the retort facility at any one time so that either may be shut down for maintenance or repair.

A movable tripper, fed by the stockpile reclaim conveyor, will distribute primary crushed shale to the secondary feed bins. These will discharge

by belt feeders onto vibrating screens that separate the shale into material larger and smaller than 3 inches. The plus 3-inch fraction will then be crushed in open circuit by tooth roll crushers set at 3 inches. The minus 3-inch fraction will be combined with crusher discharge and fed to double-deck vibrating screens that separate the material at 1/2 inch.

3.6.2.4 Material Handling

The minus 3-inch plus 1/2-inch shale, the desired feed for a vertical-type retort, will then be transported on a belt conveyor to a surge bin, from which point it will go by other belt conveyors to feed the retorts. A constant feed rate to the retorts can be controlled by a belt weigh scale that will be installed to provide automatic continuous weighing, controlled flow, and instant readouts. The fine shale (minus 1/2 inch) will be either retained for future retorting or discarded, depending on its quantity and value.

Equipment items for each line of the secondary crushing facility will be designed as full-sized units. These pieces of equipment will be used for the Phase III plant and, eventually, for the full-sized Phase IV facility. They are: movable tripper and conveyor, vibrating screens, roll crushers, belt feeders, collecting and transfer conveyor, and secondary feed bin.

The crusher building initially will house the equipment for the 10,000-TPCD plant. Provision will be made for future extensions to accommodate the equipment for the 80,000-TPCD plant and eventually for a 160,000-TPCD plant. Overhead cranes and servicing facilities will be furnished at the secondary crushing plant. Auxiliary equipment will include an extensive dust collection system, cleanup sumps and pumps, and ventilating fans.

3.6.2.5 Dust Control

Shale crushing — primary in the mine and secondary on the surface — will be a major source of dust. The primary crusher dust control system will

include water spray and wet scrubber collection, and each crusher will be equipped with a control system. Dust will be drawn down into the crusher feed hopper, through the crusher, and into a wet scrubber. The same type of system will be used for both the single-retort operation (Phase II) and the one- and two-train operations (Phases III and IV).

The wet scrubber used for the primary crusher also draws dust-laden air from the crusher discharge apron feeder and from a portion of the underground conveyor system. All points where shale is either moved from one conveyor to another or discharged will be enclosed. All of the surface conveyors will also be enclosed.

Water sprays or mechanical systems will suppress dust at the stockpile, and coarse shale from the stockpile will be conveyed by apron feeders to the secondary crushers. Each crusher-screen line will be equipped with a wet scrubber for dust control. These facilities will be used for the Phase II, III, and IV operations. The retort and loadout bins, as well as all conveyor systems, will be enclosed to control dust.

3.6.3 FIRST-TRAIN OPERATION – PHASE III

The first-train operation refers to a plant requiring up to 80,000 TPCD of oil shale to produce approximately 50,000 barrels per calendar day (BPCD) of crude shale oil. As in the single retort operation phase, the machinery will be powered by electricity.

3.6.3.1 Primary Crushing

The primary crushing facilities for the 80,000-TPCD mining operation will consist of six roll crushers and will be located at the centroid of Tract U-b. The total nominal crushing rate is 4,300 tons per hour, but the facility will be designed to allow a 25 percent increase in capacity to 5,380 tons per hour. Figure 3.6-2 shows the flow of material from primary crushing to retorting.

The minus 10-inch primary crushed product will be transported on inclined belt conveyors by a series of feeders and underground conveyors to the coarse shale stockpile on the surface.

Aside from the primary crushers and vibrating screens, the primary crushing structure will house the apron feeders, overhead crane, control room, and servicing facilities for the crushers. Auxiliary equipment will include dust suppression and collection systems and a ventilating fan and air conditioner for the control room.

3.6.3.2 Conveying — All Stages

Raw oil shale will be discharged from the primary crusher onto a belt feeder at the bottom of the crusher and transferred to a series of belt conveyors. Inclined conveyors will transport the raw shale to the surface, through an inclined entry, then through a belt conveyor system to the retorts.

Conveyors from the primary crusher to the storage pile and to the secondary crusher will be sized for the maximum design capacity of the plant, taking equipment available into account. All conveyors will be driven electrically and will be provided with belt protections and safety devices.

All surface conveyors will be enclosed to prevent dust from being blown off, and all transfer points and discharge points from conveyors to hoppers or bins or to other plant equipment will be of dust-tight construction. Conveyors will be routed to cover minimum distances with maximum slopes. Roadways will be constructed along conveyor routes to facilitate construction and provide maintenance access.

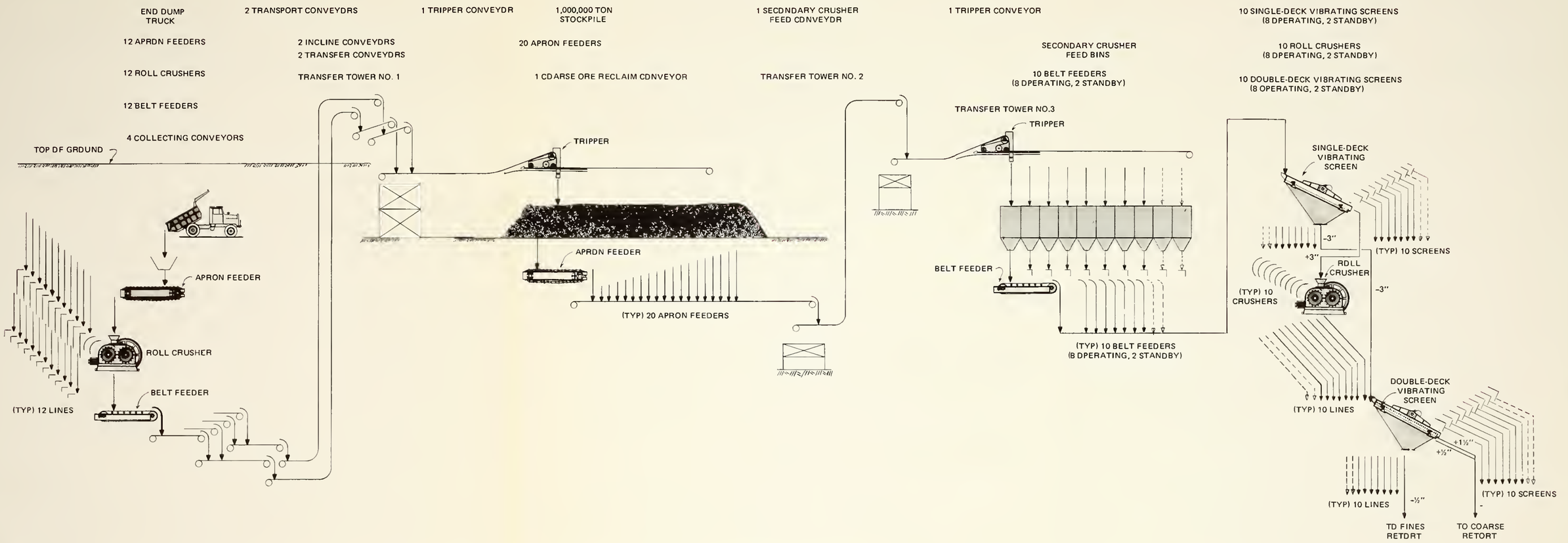


Figure 3.6-2. White River Shale Project Material Handling Flow Diagram, Phases III and IV

3.6.3.3 Stockpile

The primary crushed product will be stockpiled near the secondary crushing plant. A tripper conveyor operating in an enclosed gallery will distribute the oil shale. This raw oil shale stockpile will be in the open and will be appropriately sized to ensure continued processing when the mine and primary crusher are shut down. Present judgment estimates the required size to be approximately 1/2 million tons.

Initial stockpiling will begin during the preproduction period and will gradually build up as processing progresses.

Oil shale will be drawn from the stockpile by apron feeders onto a belt conveyor through a reclaim tunnel where dust collection will be provided. Water sprays will suppress dust during stockpiling operations. Proper drainage and water reclaim systems will also be furnished at the reclaim tunnel.

3.6.3.4 Secondary Crushing

Primary crushed shale will be reduced in five lines of secondary crushers and screens. Four of these lines, with a total nominal crushing rate of 3,400 tons per hour, will operate on a 24-hour-per-day, 365-day-per-year schedule.

Four operating lines will be designed to meet the full requirement of the plant; one line will serve as a standby in case of repairs or breakdowns. A movable tripper will distribute coarse shale to the secondary feed bins, which will then discharge by a belt feeder onto a single-deck vibrating screen. The coarse shale that passes over the screen will be fed directly to a roll crusher. The roll crusher product will be combined with the fines from the single-deck vibrating screen and discharged onto a second-stage double-deck vibrating screen.

The minus 3-inch plus 1/2-inch material will be transported by a belt conveyor to the coarse shale surge bin and the minus 1/2-inch material to the fine shale surge bin. Belt feeders will carry shale from the surge bins to a system of conveyors that feed the retort hoppers. Constant feed to the retorts will be maintained by controlling the flow rate with a belt weigh scale.

Overhead cranes and servicing facilities will be provided at the secondary crushing plant. Auxiliary equipment will include an extensive dust collection system, cleanup sumps and pumps, and ventilating fans.

3.6.4 TWO-TRAIN OPERATION – PHASE IV

The two-train operation will be sized at 160,000-TPCD mine rate to produce approximately 100,000 BPCD of crude oil. The plant will use the equipment installed for the 80,000-TPCD plant and will operate on the same process flow.

The total number of equipment lines for the primary and secondary crushing facilities and storage pile for the 80,000-TPCD plant will be doubled to a accommodate the 160,000-TPCD mine rate. The primary crushing facility will consist of 12 units: the 6 already located at the centroid of Tract U-b and 6 additional units at the centroid of Tract U-a, all underground at mine level. The total nominal crushing rate is 8,660 tons per hour, but the design will allow a 25 percent increase in capacity to 10,825 tons per hour.

Primary crushed shale will be reduced in 10 lines of secondary crushers and screens with a total nominal crushing rate of 6,700 tons per hour. The secondary crushing plant will be designed with eight operating and two standby lines.

Oil shale will be transported between intermediate points — primary crusher, stockpile, secondary crusher, surge bin, and retorts — by the conveyor system used in Phase III for 80,000-TPCD operation; this system will from its inception be designed and built for the ultimate 160,000-TPCD capacity. All auxiliary equipment, such as dust collection systems, servicing facilities, and control systems, will be expanded to meet the requirements of the two-train sized plant. To operate the plant with maximum efficiency and minimum supervision, a system of instrumentation and controls that monitor the flow and provide equipment protection will be incorporated.

Section 3.7

Section 3.7

RETORTING

This section discusses the retorting operations involved in a two-stage development program culminating in a commercial size shale oil facility. Retorting equipment and products proposed for the initial single retort operation stage are discussed as are the ultimate products and types of retorts that will be needed for a full-scale commercial plant. Flow diagrams and material balances associated with retorting operations in each of the two stages are included.

A detailed description of the various alternative retorting methods can be found in Section 7 of the Detailed Development Plan.

3.7.1 PHASED RETORT PROGRAM

A two-stage program has been planned to achieve a full-scale shale oil production facility. The two stages are:

- Single retort operation (Phase II)
- Commercial operation, which will proceed in two steps (Phases III and IV)

The objectives of the single retort operation stage will be to evaluate and assess retort technology and related mining, crushing, and material handling operations, including their environmental impact. During this stage, a single vertical-type direct heated (DH) retort will be installed and operated. After satisfactory DH operation, the retort may be modified for indirect heated (IH) operation and Phase II then extended to permit further evaluation.

Upon successful completion of the single retort stage, the commercial operation stage will begin. Additional vertical-type DH retorts, along with IH retorts and fines-type retorts, will be installed to meet the process requirements for commercial plant operation. The commercial operation stage will proceed in two steps: a first train will be built (Phase III), and a second train will be added to the first train to complete the final full-scale commercial plant (Phase IV). The first train will permit operation at 50 percent of capacity.

3.7.2 GENERAL RETORTING DESCRIPTION

The single retort operation stage (Phase II) is aimed at evaluating the vertical-type retort. Consistent with this aim, no facilities will be installed for upgrading the crude shale oil produced. Furthermore, the quantity of fines produced during large commercial scale mining and crushing of shale is undefined, as is the amount that each retort can process. Therefore, no facilities will be provided for retorting of fines during the single retort operation phase. The data obtained from this operation will permit the evaluation of what constitutes prudent resource recovery.

The commercial operation stage (Phases III and IV) will include provisions for upgrading the crude shale oil produced (see Section 3.8) and for utilizing fines. The proposed use of three different types of retorts — DH, IH, and fines-type — is based on specific process needs coupled with the requirement for high operating and thermal efficiency.

The crude shale oil produced by the retorts will be upgraded by hydrotreating, which will require a supply of hydrogen. The commercial facility will include a hydrogen manufacturing plant fed by high-Btu gas. The fines-type retorts, in addition to processing fines, will generate high-Btu gas which, after treating, will be suitable for hydrogen plant

feed. However, the quantity of gas produced by retorting fines will not furnish sufficient feed for the hydrogen plant. The vertical-type retorts, when operated in the IH mode, will also generate high-Btu gas which, after treating, will be satisfactory for hydrogen plant feed. Therefore, the IH retorts will be included in the commercial plant to provide sufficient capacity for generating the high-Btu gas required for the hydrogen plant.

3.7.3 VERTICAL-TYPE RETORTS – DH AND IH

Two modes of operation are possible with the vertical-type retort:

- Direct heated (DH) mode – in which the heat of retorting is supplied by introducing air directly into the retort to burn the carbonaceous processed shale residue and a portion of the retorted gas and oil within the retort
- Indirect heated (IH) mode – in which the heat of retorting is supplied by introducing an externally heated recycle gas stream

From an equipment standpoint, the major difference between the two modes of operation is the addition of an external heater for the IH mode. This is shown schematically in Figures 3.7-1 and 3.7-2.

3.7.3.1 Mechanical Description

A general layout of the proposed vertical-type DH retort is shown in Figure 3.7-3. The significant items of equipment include the retort, the condenser, the precipitator, and blowers for air, recycle gas, and product gas. The IH retort would be essentially the same except for the addition of an external heater for recycle gas.

3.7.3.2 Process Description

Raw shale from the feed bin in a size range of approximately 1/2 inch to 3 inches will flow down the retorts. The rock will initially be preheated

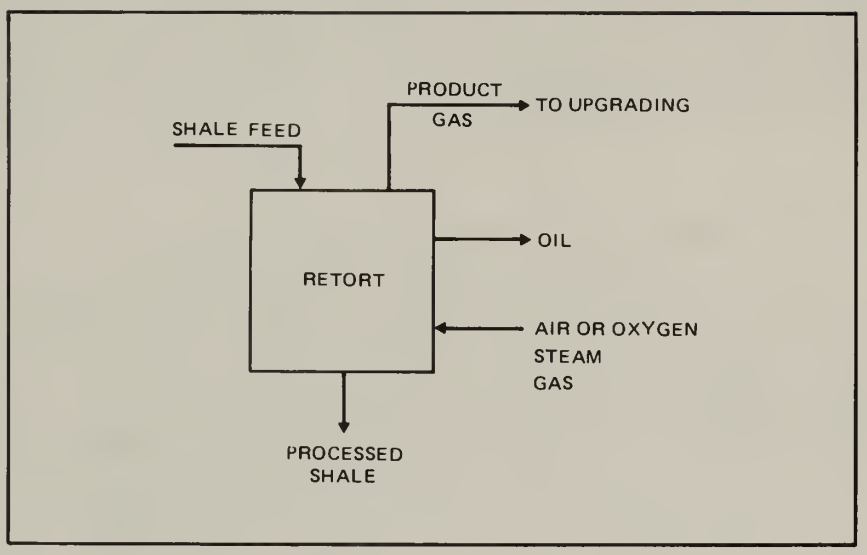


Figure 3.7-1. Direct Heated (DH) Retorting System

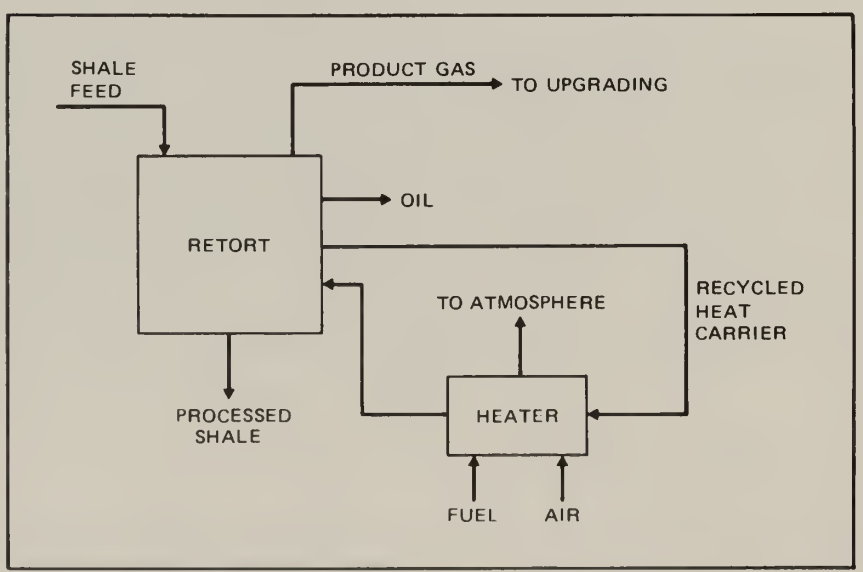


Figure 3.7-2. Indirect Heated (IH) Retorting System

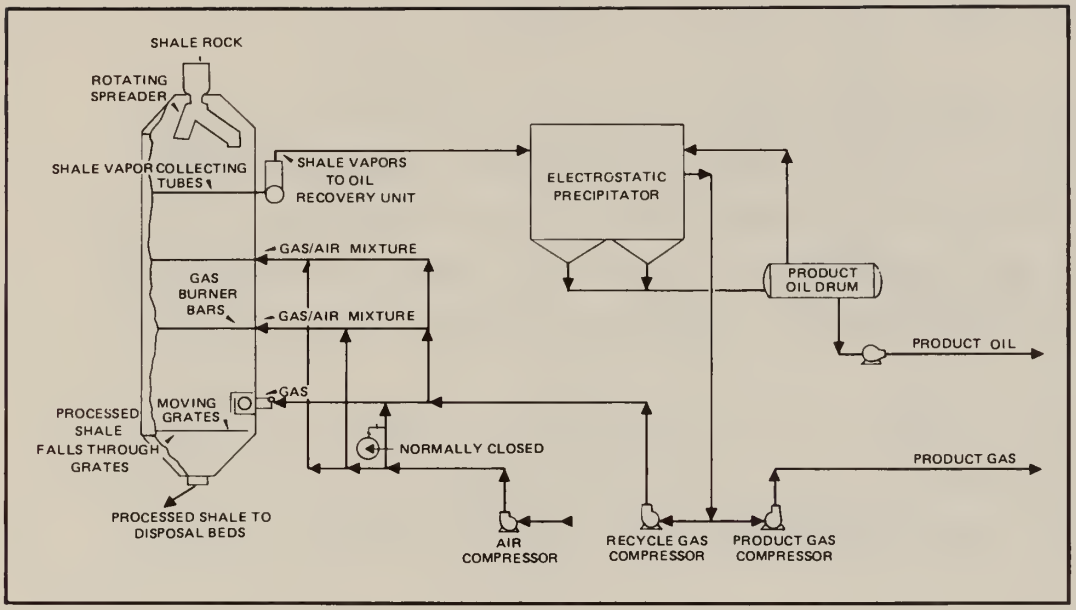


Figure 3.7-3. Proposed Vertical-Type DH Retort

by cooling the ascending gas and oil mist to about 170°F. The shale will next contact recycle gas that has been heated by burning residual carbon from the processed shale (DH mode) or that has been heated to about 1,100°F in a fired heater (IH mode). In this zone, the raw shale will reach temperatures sufficient to pyrolyze the organic kerogen.

The retorting temperatures will also cause decomposition of mineral carbonates, principally calcite and dolomite. In the bottom section of the bed, heat will be recovered by cooling the processed shale through contact with a cool recycle gas.

Both the retort product gas and the oil mist will flow to gas-liquid separators. Recovered product oil will flow to an oil surge drum, from which it will be pumped either in-line to downstream processing or through a tempered cooler to storage. Cooling the shale oil will lower its vapor pressure and permit storage in a cone-roof tank.

The product gas, either low-Btu (DH mode) or high-Btu (IH mode), will be compressed and sent to appropriate treatment facilities for hydrogen sulfide removal before being used as fuel or hydrogen plant feed.

Processed shale will leave the retorts and be conveyed to rotary moisturizing drum coolers, which will cool the shale and suppress dust. Dust-laden steam and moist air produced in this step will pass through high-efficiency wet scrubbers, where the steam will be condensed and dust removed from the air. Clean warm air leaving the scrubbers will be vented and the dust-laden steam condensate clarified for reuse. After cooling and dust suppression, the processed shale, with a moisture content of 5 to 10 percent, will pass on conveyors to the disposal area.

As is evident from this description, retorting will be complex and will clearly require a development phase of single retort operation at full scale to refine the design parameters, material selection, and redundancy requirements for the commercial design.

3.7.3.3 Flow Diagram

The Phase II retorting plan, which uses a single vertical-type DH retort, is illustrated in Figure 3.7-4. Approximate overall quantities of raw materials and products are indicated.

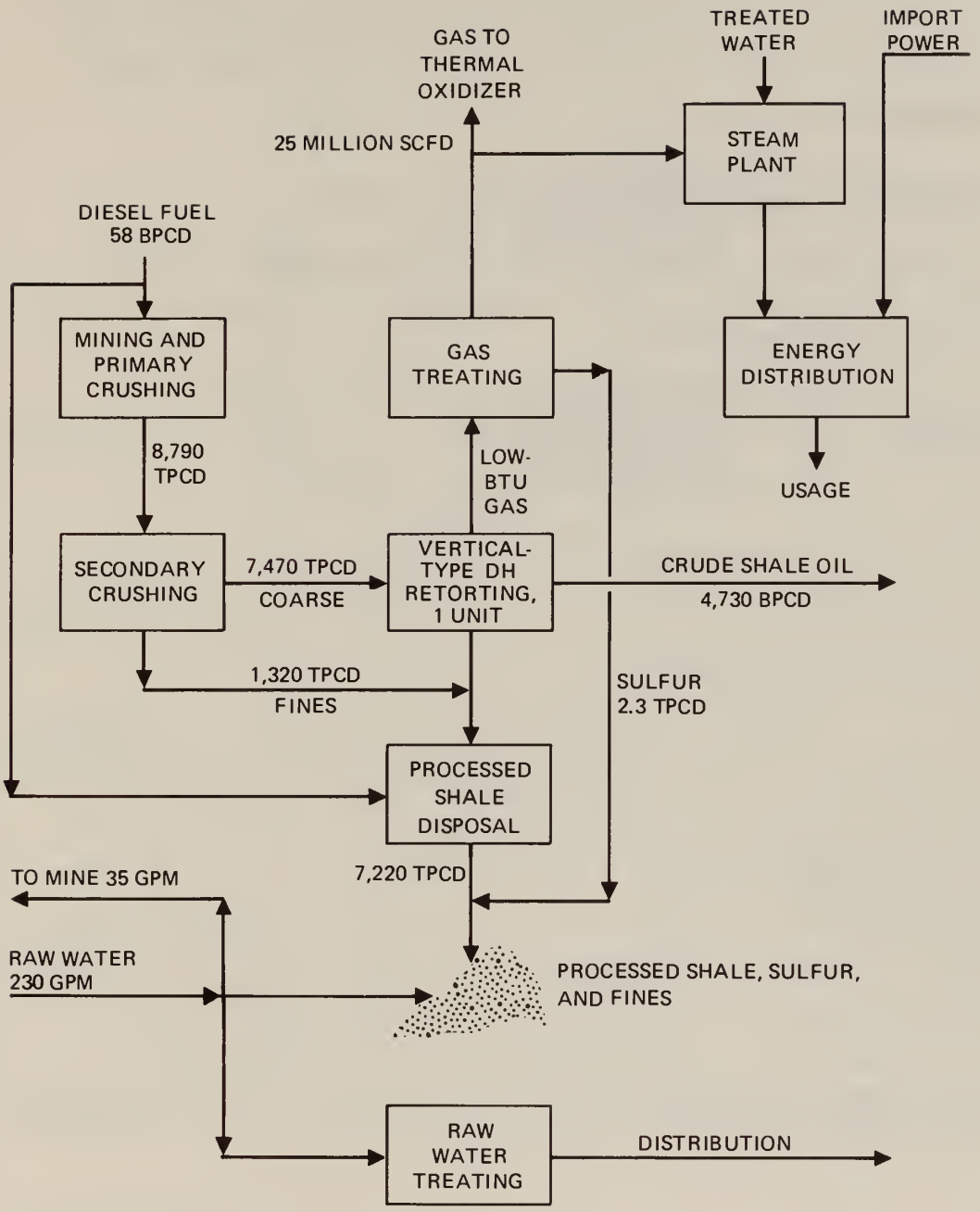


Figure 3.7-4. White River Shale Project Flow Diagram, Phase II

A block flow diagram for the full-scale commercial plant retorting operations is shown in Figure 3.7-5. This diagram includes secondary crushing and sizing, processed shale disposal, and all three types of retorts.

3.7.3.4 Material Balance

A retorting material balance for the commercial plant is given in Table 3.7-1. The combined inputs and outputs for all retorts are shown in this table.

Table 3.7-1

RETORTING MATERIAL BALANCE

Component	TPCD	Wt %	°API	BPCD (Million SCF/CD)
Mined and crushed shale	159,600	88.0	—	—
Air	21,730	12.0	—	(569)
Total in	181,330	100.0	—	
Low-Btu gas (dry)[(a)]	32,580	18.0	—	(815)
High-Btu gas (dry)[(a)]	1,269	0.7	—	(35)
Crude shale oil	16,361	9.0	19.8	100,000
Water	1,689	0.9	—	—
Processed shale	129,431	71.4	—	—
Total out	181,330	100.0		

(a) Gas quantities shown are before fuel consumption

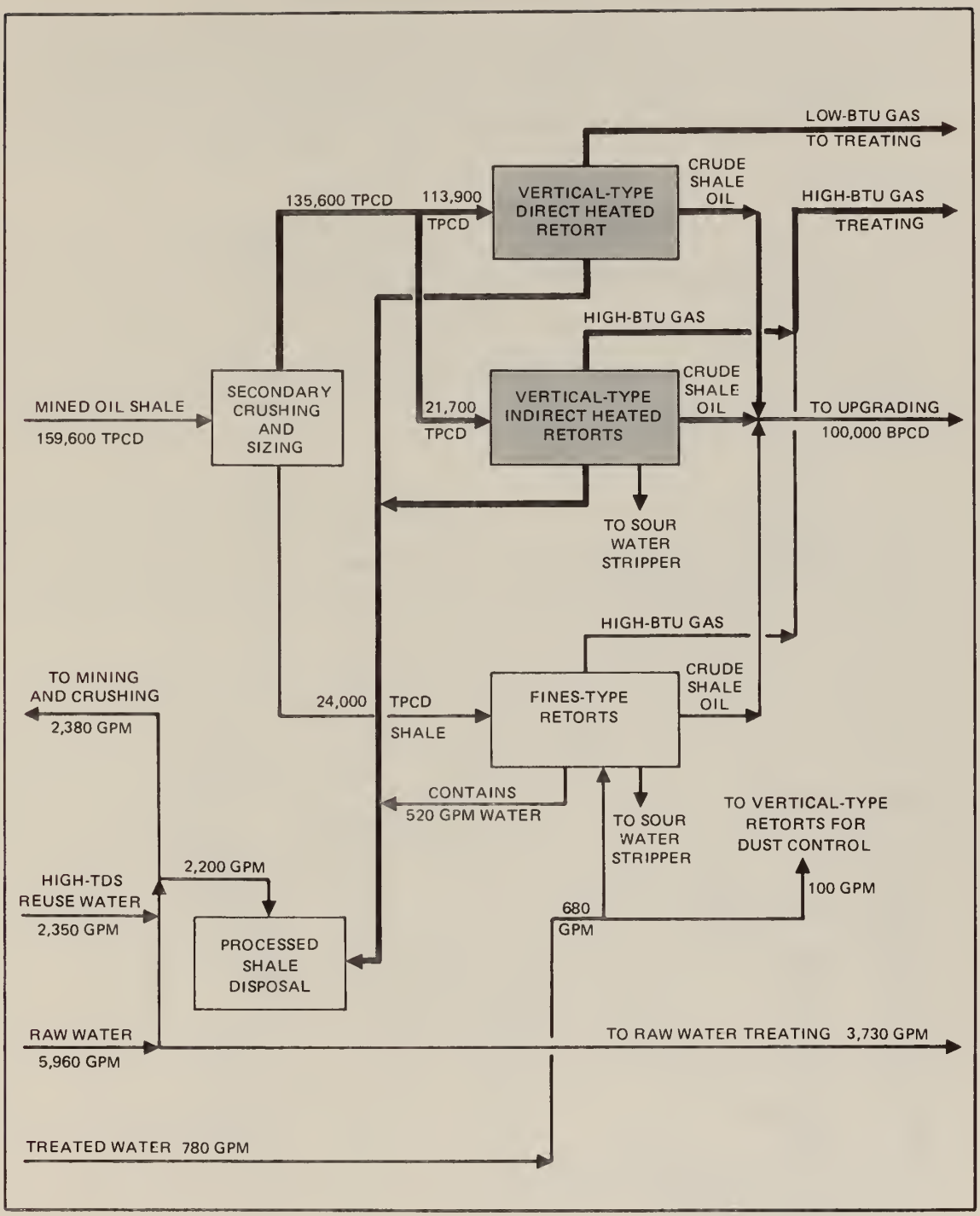


Figure 3.7-5. Flow Diagram, Phases III and IV — Emphasizing Vertical-Type Retorts

3.7.3.5 Characteristics of Products and Effluents

The composition of the crude shale oil produced by the vertical-type DH and IH retorts is indicated in Table 3.7-2. The corresponding gas composition from these retorts is shown in Table 3.7-3.

Table 3.7-2

ESTIMATED CRUDE SHALE OIL COMPOSITION
VERTICAL-TYPE DH AND IH

Oil Composition	Vertical-Type DH and IH
°API	19.5
Sulfur, wt %	0.7
Nitrogen, wt %	2.1
Distillation	
C_5-430°F, vol %	5
430°F-600°F, vol %	15
600°F+, vol %	80

Table 3.7-3

ESTIMATED GAS COMPOSITION – VERTICAL-TYPE DH AND IH

Gas Composition	DH Vol %	IH[(a)] Vol %
N_2	61.0	1.8
O_2	0.1	–
H_2	4.9	36.6
CO	2.9	7.3
CO_2	22.8	21.2
H_2S	0.1	2.0
C_1	2.1	20.5
C_2's	1.1	6.5
C_3's	0.6	1.2
C_4's	0.3	0.6
H_2O	4.1	2.3
Total	100.0	100.0

(a) After compression, cooling, and water KO drum

3.7.4 FINES-TYPE RETORTS

The fines-type retorting process uses an indirect heating mode to pyrolyze and recover kerogen from finely crushed oil shale. Additional information on fines-types retorts is found in Section 7.7.

3.7.4.1 Mechanical Description

The various parts of the fines-type retort system are shown in Figure 3.7-6. This simplified schematic indicates the major functional items of equipment, but does not show individual subcomponents of the process equipment.

3.7.4.2 Process Description

Raw oil shale is first contacted with ball heater flue gas to preheat the solids before delivery into the pyrolysis drum. The shale preheater and

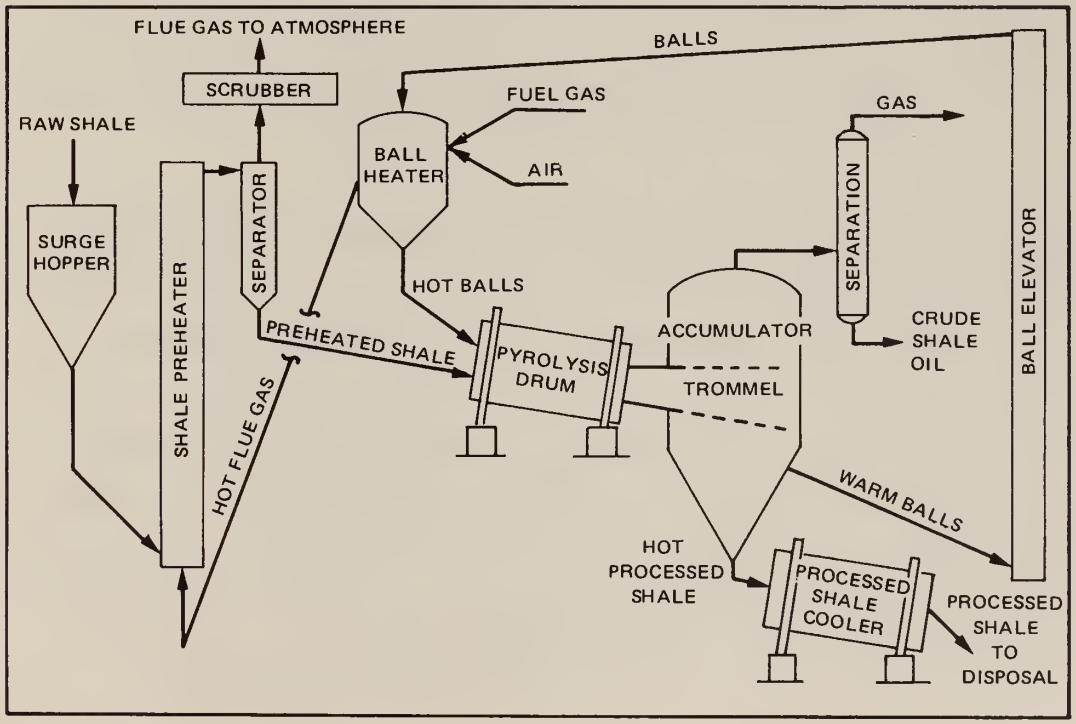


Figure 3.7-6. Fines-Type Retort System

separator shown in Figure 3.7-6 actually consist of a series of three lift pipes and accumulators.

Complete pyrolysis of the kerogen in the raw shale is accomplished in the pyrolysis drum by contacting the preheated shale with heated ceramic balls. In the pyrolysis drum, the crushed shale and ceramic balls are mixed to effect heat transfer and pyrolysis. The pyrolysis drum discharges directly into the accumulator.

Processed shale and balls from the drum are separated in a cylindrical trommel located within the accumulator. The warm balls pass from the accumulator to a ball elevator, while the processed shale discharges from the bottom of the accumulator to the processed shale cooler. Vaporized product shale oil and gas exist from the top of the accumulator.

Processed shale cooling is accomplished in two stages. In the first stage, the hot processed shale from the trommel is cooled in a rotating steam generator. In the second stage, the processed shale is cooled further by direct water quench in another rotating vessel. The cooled, moisturized shale is then delivered to the processed shale disposal.

The ball elevator returns the balls to the ball heater, where they are heated to the required temperature by the combustion of fuel gas. The hot flue gases, after heating the balls, pass to the shale preheater.

Vaporized crude shale oil and gases are routed to a separation system, where the crude shale oil is condensed in a direct contact cooler using cooled recirculating shale oil. Hot vapors are further cooled to recover additional oil before the gas is compressed to the required pressure for downstream treatment to remove hydrogen sulfide.

3.7.4.3 Flow Diagram

A block flow diagram for the commercial plant retorting operations is shown in Figure 3.7-7. This diagram includes secondary crushing and sizing, processed shale disposal, and all three types of retorts. The fines-type retorting is shaded for emphasis.

3.7.4.4 Material Balance

A retorting material balance for the full-scale commercial plant was presented in Table 3.7-1. The combined inputs and outputs for all retorts were given in this table.

3.7.4.5 Products/Effluents Characteristics

The crude shale oil produced by the fines-type retorting system has the composition shown in Table 3.7-4. The composition of the gas from this system is indicated in Table 3.7-5.

Table 3.7-4

ESTIMATED CRUDE SHALE OIL COMPOSITION
FINES-TYPE RETORT

Oil Composition	
^{o}API	22.0[(a)]
Sulfur, wt %	0.7
Nitrogen, wt %	1.9
Carbon, wt %	84.9
Hydrogen, wt %	11.3
Distillation, vol %	
IBP-100^{o}F	18.0
400^{o}F-600^{o}F	24.0
600^{o}F-900^{o}F	34.0
900^{o}F+	24.0

(a) Condensation of C_5's, C_6's, and C_7's in the gas produced 25.2^{o} API C_5+ oil[5].

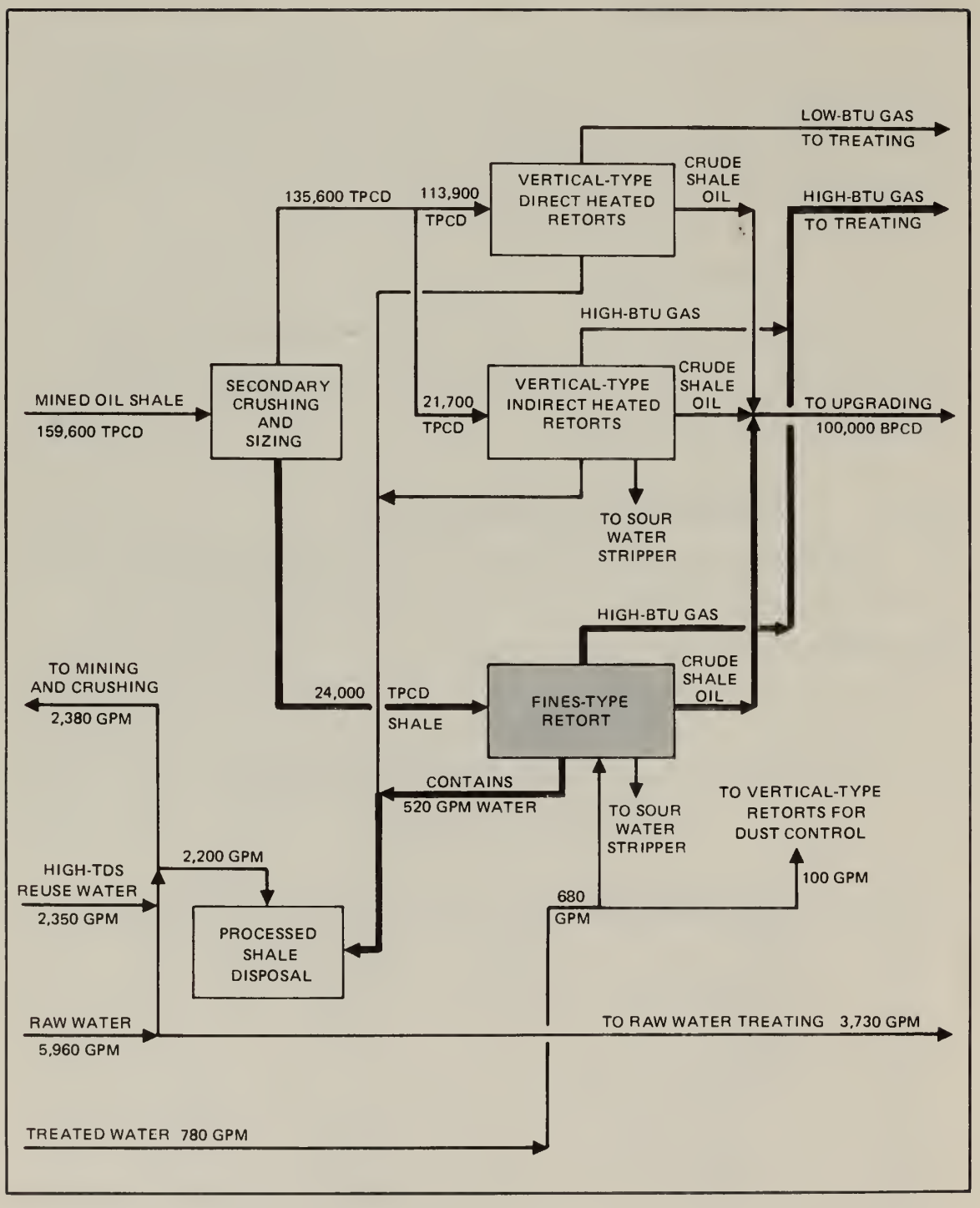


Figure 3.7-7. Flow Diagram, Phases III and IV — Emphasizing Fines-Type Retorts

Table 3.7-5

ESTIMATED GAS COMPOSITION
FINES-TYPE RETORT

Gas Composition[a]	Wt % of Sample
H_2	1.34
CO	3.14
C_1	10.66
$C_2^=$	7.75
C_2	7.53
$C_3^=$	9.90
C_3	4.87
$C_4^=$	6.07
C_4	3.94
C_5's	6.14
C_6's	3.60
C_7's	0.89
CO_2	29.56
H_2S	4.61
	100.00

(a) Does not include flashed light naphtha

3.7.5 POLLUTION CONTROL PROGRAM

In the retorting process, potential leakage of the gaseous product and dust emission from raw shale feed and from processed shale discharge are primary concerns. Baghouses or wet scrubbers will be installed to control dust emission from the feed and discharge equipment. A double seal incorporating injection of clean purge gas between the seals will be used to minimize gas leakage from the retorts. Emission rates, pollution control plans, and effects on the ambient air quality are further discussed in Sections 4.2 and 5.2.

Section 3.8

Section 3.8

UPGRADING

This section discusses the phased installation of two process trains for upgrading the crude shale oil produced by the retorting operations in the commercial plant; presents a proposed upgrading scheme to produce refined shale oil, diesel fuel for mining, and fuel for process and utility plant requirements; and describes process units and supporting process facilities needed for upgrading the crude shale oil, including hydrotreating, light ends compression, gas (amine) treating, hydrogen production, sulfur recovery, and sour water treating. Flow diagrams and material balances associated with the upgrading and ancillary operations are included.

3.8.1 PHASED UPGRADING PROGRAM

The upgrading process design is based on a two-train concept that will permit operating flexibility and ensure continuity of operations. The two trains will be installed sequentially, with a delay of approximately 1-1/2 years between completion of the trains. Startup of the first train will permit 50 percent capacity operation, with a 50 percent turndown ratio to a 25 percent minimum operating level. The second train startup, about 18 months later, will give 100 percent capacity operation potential with 75 percent turndown flexibility.

Process units required for starting up at 50 percent of ultimate capacity are shown in Table 3.8-1.

Table 3.8-1

SHALE OIL PROCESS UNITS

Process Unit	Number of Units		Interim Percent of Ultimate Capacity	Interim Operating Load Percent of Installed
	Ultimate	Interim		
Crude shale oil hydrotreater	2	1	50	100
Naphtha hydrotreater	1	1	100	50
Low-Btu gas treating	1	1	100	50
Light ends recovery	2	1	50	100
Hydrogen plant	2	1	50	100
Sour water stripping	1	1	100	50
Wastewater treatment	1	1	100	50
Amine plant	2	1	50	100
Sulfur plant	2	1	50	50
Tail gas unit	1	1	100	50

3.8.2 GENERAL UPGRADING DESCRIPTION

The 100,000 BPCD of crude shale oil produced by retorting will be processed in two parallel hydrotreating units, followed by additional naphtha hydrotreatment, to yield 107,560 BPCD of C_5^+ refined shale oil. Some refined shale oil will be used as process and utility plant fuel, and a small amount will supply the requirements for diesel fuel in the mining operation. The net yield of upgraded shale oil product will be 96,000 BPCD.

Supporting process facilities will comprise light ends compression, hyrogen production, amine gas treating, sulfur recovery and tail gas treating,

wastewater treating, and sour water stripping. Supporting offplot facilities will consist of storage, product movement, relief and blowdown, utlities, water supply, wastewater treatment, solid waste handling, and maintenance and administrative facilities.

After the facility process fuel and hydrogen plant feed requirements are furnished, there will be a surplus of low-Btu gas. This gas, together with refined shale oil, will be used to generate the power requirement for the facility. With the exception of raw water, the oil shale facility will normally require no purchased utilities.

3.8.3 HYDROTREATING

Crude shale oil produced from retorting will have a gravity of 19.8° API, a pour point of 85°F, a viscosity of 460 centistokes at 40°F, and will contain 2.1 wt % nitrogen, 0.7 wt % sulfur, and 1.5 wt % oxygen.

Shale oil hydrotreating will consist of hydrogenation of the crude shale oil and hydrotreatment of naphtha; the component fractions of the upgraded shale oil product will be suitably low in nitrogen for subsequent routine processing in refineries. Conventional petroleum technology has been used as a basis for the crude shale oil hydrotreating.

Sufficient naphtha will be produced by hydrocracking to make the product viscosity low enough for pipelining purposes. However, if the upgraded shale oil pour point exceeds the specification for pipelining, a suitable pour point depressant will have to be added. The upgraded shale oil viscosity of 13 centistokes at 40°F (minimum pipeline temperature) is such that, with the use of a suitable pour point depressant, the upgraded shale oil will be pipelinable.

3.8.3.1 Mechanical Description

Because of reactor size limitations (multiple reactors will be required) and to provide operating continuity, two crude shale oil hydrotreating units will be furnished. Each hydrotreating unit will be designed to process 55,000 BPSD of crude shale oil.

The components of a typical hydrotreater for this services are shown in Figure 3.8-1. A typical naphtha hydrotreater is illustrated in Figure 3.8-2.

3.8.3.2 Process Description

The crude shale oil hydrotreater will be a once-through unit with a high catalyst selectivity for hydrogenation of nitrogen and sulfur compounds. The desired denitrification and desulfurization of the 400°F+ true boiling point (TBP) material will be accomplished in this unit. The naphtha fraction produced must be separated and further treated in a separate hydrotreater for additional denitrification.

The high catalytic selectivity of these units will limit hydrocracking and, therefore, hydrogen chemical consumption to approximately 1,700 SCF per barrel of crude shale oil feed. The extent of hydrocracking will be sufficient to reduce the pour point to 50°F.

Ammonia and hydrogen sulfide will be removed from the crude shale oil hydrotreating unit by water-washing the recycle gas. Sour wash water will be sent to the wastewater treating plant, where the water will be stripped of hydrogen sulfide and ammonia; stripped water will be recycled to the hydrogreating units.

The hydrogreated shale oil will be stripped of light ends and fractionated to recover a C_5 400°F-TBP naphtha fraction, which will be routed to the naphtha hydrotreating unit for further processing.

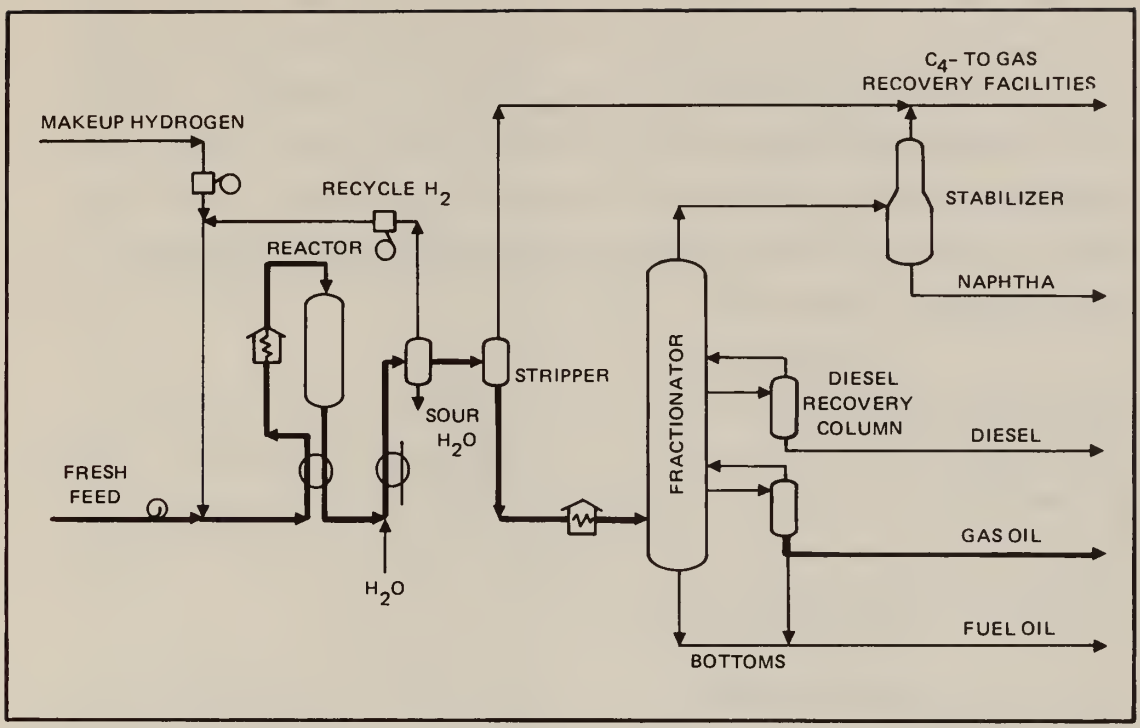


Figure 3.8-1. Typical Hydrotreater

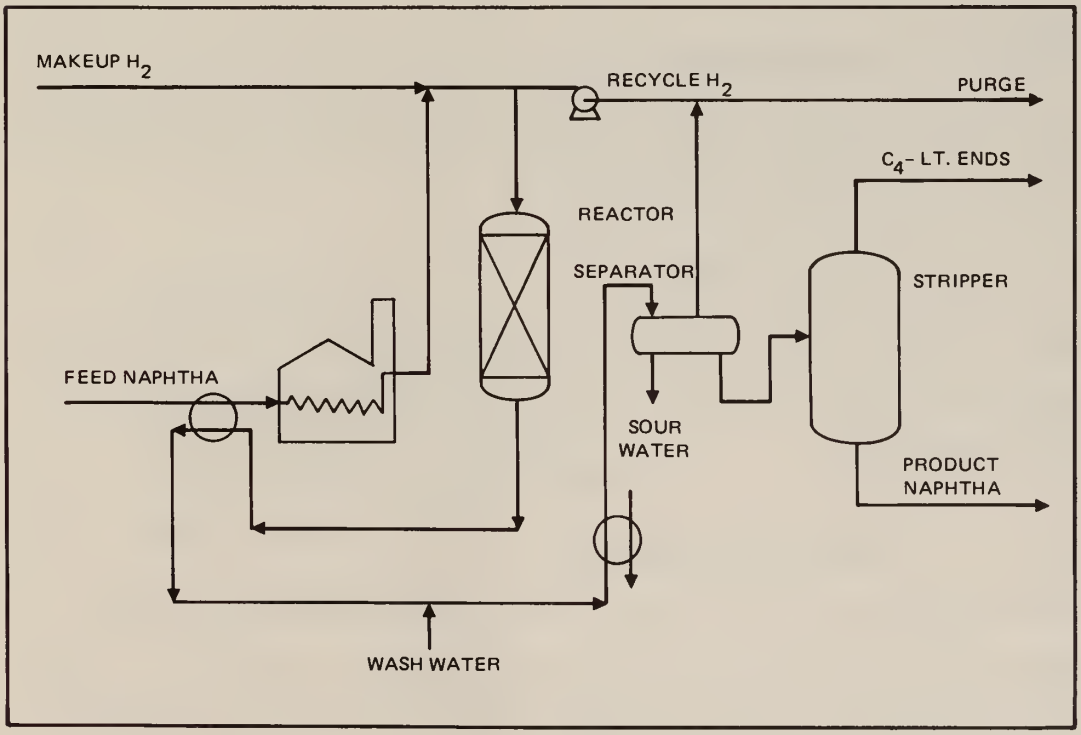


Figure 3.8-2. Typical Naphtha Hydrotreater

A slipstream of 400°F+ TBP bottoms from the fractionator will be fed to a small diesel recovery column to recover 1,080 BPCD of diesel fuel for use in the mining and processed shale disposal operations. The resulting 600°F+ TBP bottoms will be combined with 400°F+ TBP oil to provide 10,480 BPCD of fuel oil for process heaters and for the utility plant. A single diesel fuel recovery column will serve the two crude shale oil hydrotreating units.

Partially hydrotreated naphtha recovered from each crude shale oil hydrotreating unit and C_5^+ recovered from the light ends compression facilities will be processed in a conventional naphtha hydrotreating unit to reduce the nitrogen content from 100 ppmw* to about 1 ppmw. One high-reliability naphtha hydrotreating unit will be provided.

The 400°F+ TBP hydrotreated oil will be cooled to 150°F and recombined with naphtha from the naphtha hydrotreating unit, and the combined product will be sent to upgraded shale oil storage.

3.8.3.3 Flow Diagram

A block flow diagram for the full-scale commercial plant upgrading operations is shown in Figure 3.8-3.

3.8.3.4 Material Balance

Table 3.8-2 gives an overall material balance for the crude shale oil upgrading and product recovery. Hydrotreating inputs and outputs are included in this table.

3.8.3.5 Product Characteristics

The outputs from the crude shale oil hydrotreater and naphtha hydrotreater will be combined to form upgraded shale oil. Tables 3.8-3 and 3.8-4 summarize the characteristics of the upgraded shale oil product.

*Parts per million by weight

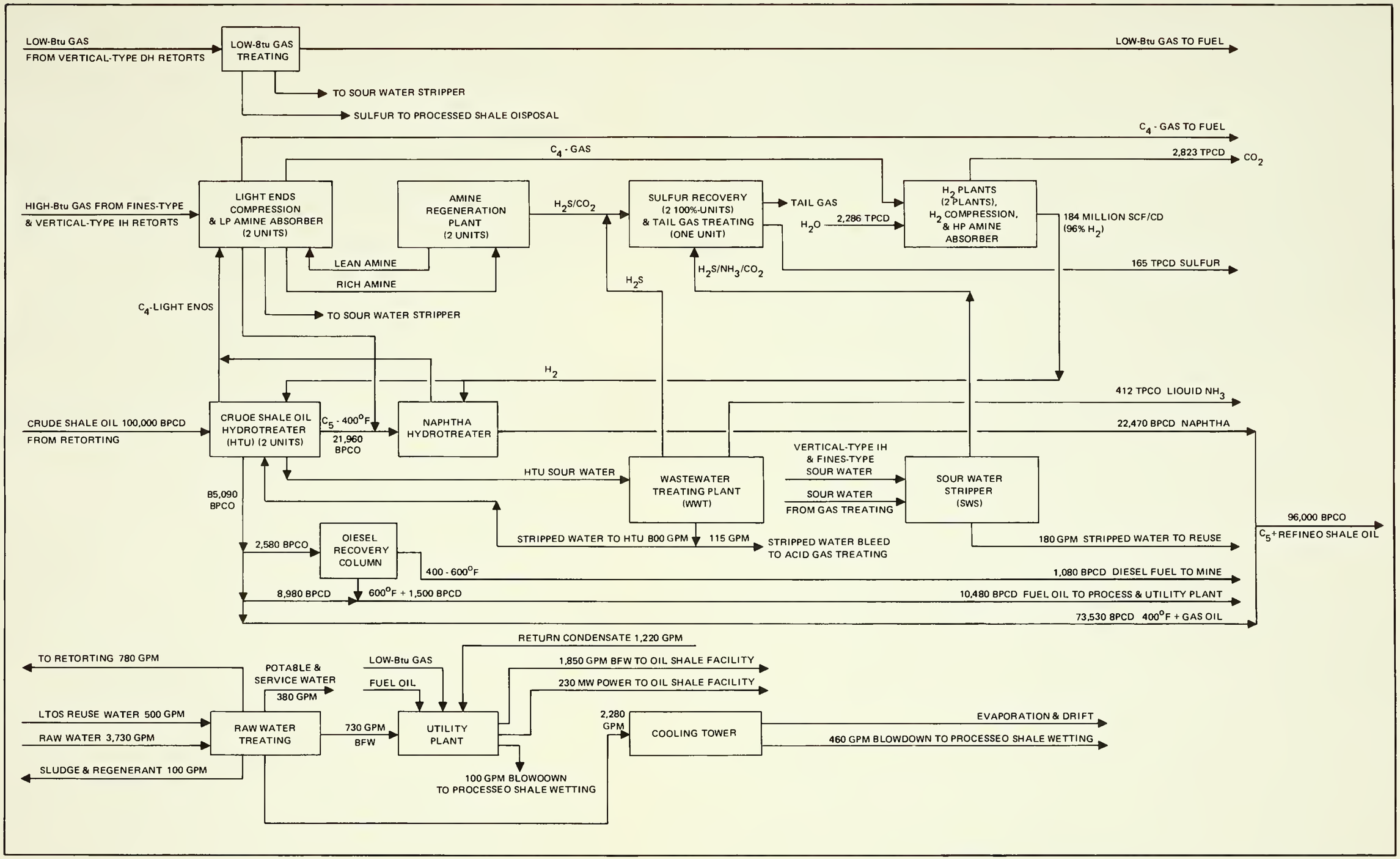


Figure 3.8-3. Commercial Plant Upgrading Operations — Block Flow Diagram

Table 3.8-2

UPGRADING MATERIAL BALANCE

Processing Component	TPCD	Wt %	°API	(Million SCF/CD) BPCD	Liquid Hydrocarbon Yield, Volume % of Crude Shale Oil
High-Btu gas	1,269	6.2	–	(35)	–
Water to H_2 plant	2,286	11.3	–	–	–
Air to sulfur plant	358	1.8	–	–	–
Crude shale oil	16,361	80.7	19.8	100,000	100.0
Total in	20,274	100.0			100.0
High-Btu gas[a]	168	0.8	–	(4)	–
CO_2 from H_2 plant	2,823	13.9	–	–	–
Naphtha	2,925	14.4	58.5	22,470	22.5
Gas oil[b]	12,646	62.5	35.0	85,090	85.1
Sulfur	165	0.8	–	–	–
Ammonia	412	2.0	–	–	–
Water produced	283	1.4	–	–	–
Sulfur plant tail gas	852	4.2	–	–	–
Total out	20,274	100.0			107.6
Net products component					
C_5+ refined shale oil[b]	13,850	84.7 [c]	40.0	96,000	96.0
Sulfur	165	1.0 [c]	–	–	–
Ammonia	412	2.5 [c]	–	–	–
Total	14,427	88.2 [c]		96,000	96.0

(a) Gas and gas oil quantities shown are before fuel consumption.
(b) Diesel fuel for mine and processed shale disposal is 1,080 BPCD.
Refined shale oil (400°F+) burned as fuel for process units and utility plant is 10,480 BPCD.
(c) Yield and wt % of crude shale oil.

Table 3.8-3

ESTIMATED UPGRADED SHALE OIL PROPERTIES

Output	96,000 BPCD
Pour point	50°F
Gravity	40.0°API
Viscosity @ 40°F/100°F	13 CS/4 CS
Sulfur content	0.025 wt % (max.)
Nitrogen content	0.034 wt %

Table 3.8-4

ESTIMATED UPGRADED SHALE OIL
COMPONENT VOLUMES AND PROPERTIES

	BPCD	°API	Nitrogen (ppmw)	Sulfur (ppmw)	Pour Point (°F)
C_5-400°F TBP naphtha	22,470	58.2	1	–	-60
400°F-600°F TBP LGO	30,830	38.3	200	< 50	0
600°F+ TBP HGO	42,700	32.2	600	<500	100
Total	96,000	40.0	340	250	+50

3.8.4 HYDROGEN PLANT

Total hydrogen required by the hydrotreating units will be 196 million standard cubic feet per stream day (SCFSD), which will be produced in two hydrogen plants. Because hydrogen will be recovered from the hydrotreating units and produced in the retorting plant (available in the high-Btu gas), actual chemical production will be only 184 million SCF/SD.

Feed gas to each hydrogen plant will first be treated to remove sulfur compounds and saturate any olefins. Before being fed to the reformer, the feed gas will be passed through zinc oxide beds for removal of trace quantities of sulfur compounds.

The gas leaving the reformer will contain carbon monoxide and hydrogen. The carbon monoxide will be shifted to carbon dioxide, which can be readily absorbed and stripped from the system. Since carbon monoxide is detrimental to the hydrotreating catalyst, small quantities of carbon monoxide remaining with the hydrogen gas will be converted to methane.

3.4.4.1 Mechanical and Process Description

Figure 3.8-4 illustrates a conventional steam-hydrocarbon reforming hydrogen plant typical of the kind what will be used to provide hydrogen

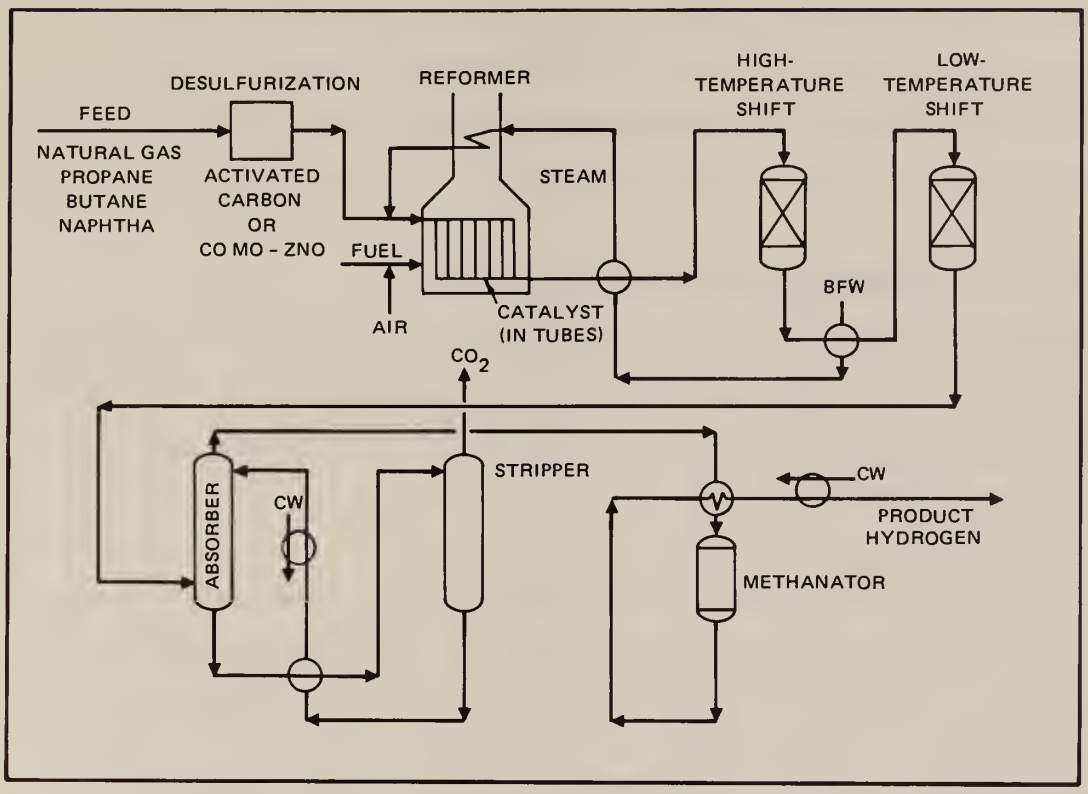


Figure 3.8-4. Typical Steam-Hydrocarbon Reforming Hydrogen Plant

for the hydrotreating units. Satisfying equipment size limitations and matching the crude shale oil hydrotreaters will require two hydrogen plants.

3.8.4.2 Flow Diagram

A block flow diagram illustrating the hydrogen plant operation is shown in Figure 3.8-3.

3.8.5 LIGHT ENDS RECOVERY AND AMINE TREATING

Gases (light ends) produced by the retorts and by hydrotreating crude shale oil will contain acid gases (hydrogen sulfide and carbon dioxide) as impurities. Before the light ends can be used for hydrogen plant feed, these acid gases must be removed. In addition, the gases will also contain small amounts of heavier material that can be removed by condensation and recovered for additional feed to the naphtha hydrotreater.

A recirculating stream of diethanolamine will be used to remove the impurities from the gases; hence, the term "amine treating" to describe this process. Heavy ends will be removed by compressing to higher pressures and cooling the gases to condense the heavy fractions.

3.8.5.1 Mechancial and Process Description

A simplified schematic diagram of the equipment proposed for recovery and amine treating of the light ends is shown in Figure 3.8-5. Two units will be required to match the two crude shale oil hydrotreating units and two hydrogen plants.

Fines-type and vertical-type IH retort gases will be compressed, cooled, and separated from the liquid phases (sour water and hydrocarbons). The gas phase will enter an absorber where it will be contacted by a lean amine solution. The acid gases will react with the amine to form salts, which will then pass to the stripper as rich amine. In the stripper, heat will be applied to decompose the salts and regenerate the lean amine, which will be returned to the absorber. Hydrogen sulfide and carbon dioxide leaving the stripper will be sent to the sulfur recovery plant.

The treated gas leaving the absorber will be separated into two streams: a small portion will be bled off to the high-Btu fuel system, and the bulk of the gas will be combined with the hydrotreating unit light ends and compressed to hydrogen plant feed pressure. At this pressure, the gas will be cooled, the liquid phase separated, and the gas washed with lean oil (C_5^- from the crude shale oil hydrotreating unit) to remove traces of the remaining heavy ends. The gas will then be passed to the hydrogen plant where it will be treated for further hydrogen sulfide removal and final desulfurization.

Condensate and rich oil from the light ends recovery will be fed to the naphtha hydrotreating unit. Sour water from the phase separators will be sent to the sour water stripper.

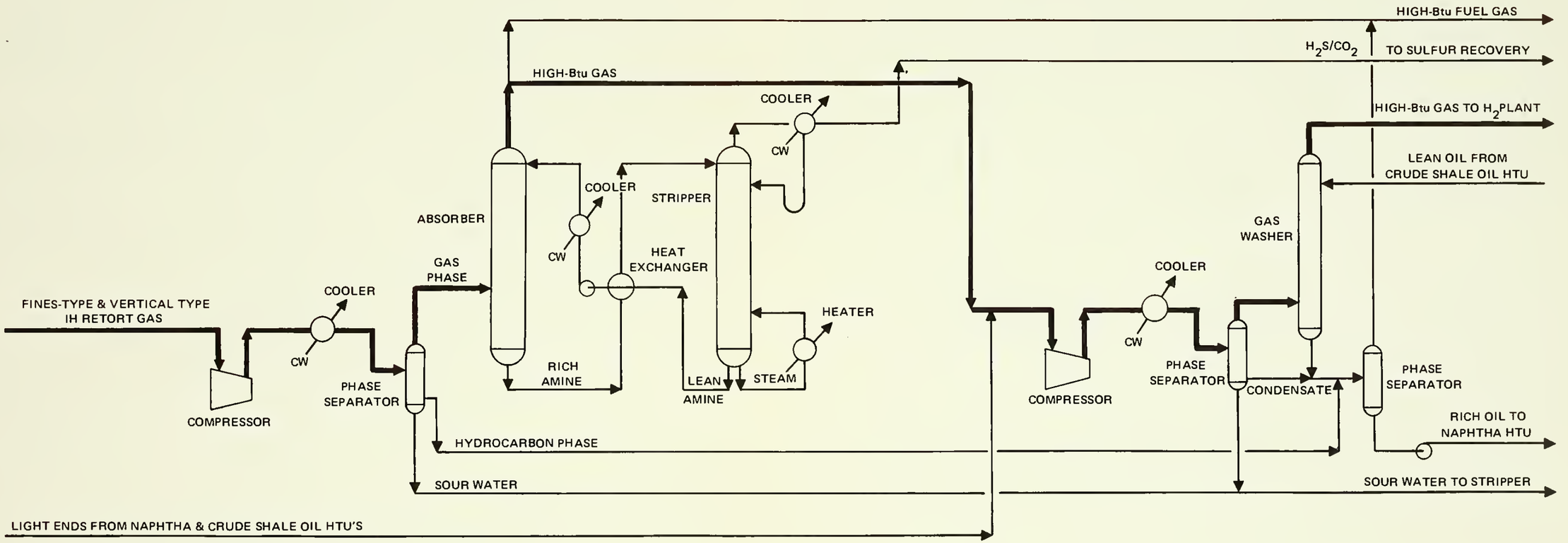


Figure 3.8-5. Light Ends Recovery and Amine Treating – Schematic Drawing

3.8.5.2 Flow Diagram

A block flow diagram illustrating the light ends processing is shown in Figure 3.8-3.

3.8.6 SUPPORTING PROCESSES

As shown in Figure 3.8-3, the supporting processes for the upgrading units will consist of low-Btu gas treating, sulfur recovery with tail gas treating, wastewater treating, and sour water stripping.

3.8.6.1 Low-Btu Gas Treating

Since the low-Btu gas generated from the vertical-type DH retorts will contain small quantities of hydrogen sulfide and ammonia, it will require treating before it can be used for fuel gas.

The gas will be water-washed to remove ammonia prior to sulfur removal. Wash tower bottoms, containing mainly carbon dioxide and ammonia, will be fed to the sour water stripper.

The washed low-Btu gas will be passed through a Stretford sulfur plant for removal of hydrogen sulfide, which will subsequently be converted to sulfur. Sulfur recovered from the Stretford solution will not be of salable quality; therefore, the small amount produced will be disposed of with the processed shale.

3.8.6.2 Sulfur Recovery and Tail Gas Treating

Two 100-percent-of-capacity sulfur recovery plants are proposed with a single tail gas treating unit. Both sulfur plants will be of conventional design and will have three catalytic converter stages. The tail gas unit will handle the waste flue gas from the sulfur plant and will employ the licensed technology of Davy Powergas (Wellman-Lord); the tail gas will meet or exceed applicable standards.

Two 100-percent sulfur recovery plants were selected to ensure the availability of a spare unit. Because of the high reliability of the tail gas treating unit and because of the ability of the plant to continue operations temporarily without this unit, only one tail gas treating unit will be needed. A total of 165 TPCD of sulfur will be produced by this facility.

3.8.6.3 Wastewater Treating

Sour water from the hydrotreating units will be processed in the wastewater treating plant to recover hydrogen sulfide (sulfur plant feed), anhydrous liquid ammonia as a net product, and stripped water, which will be recycled to the hydrotreating units. The wastewater treating plant design is based on Chevron Research Company technology (Ref. 35).

Owing to the demonstrated reliability of the process, only one wastewater treating plant will be needed. When a wastewater treating plant shutdown is necessary, boiler feedwater can be used as hydrotreating unit wash water, and the resulting accumulation of sour water can be stored. Storage capacity will be provided in the facility for 5 days' production of sour water.

3.8.6.4 Sour Water Stripper

The sour water stripper, which will be of conventional design, will process sour water from fines-type and vertical IH retorts and from low-Btu gas treating. This water will contain ammonia, carbon dioxide, phenols, chlorides, and other contaminants. Acid gas from the sour water stripper will be sent to the sulfur plant. The sour water stripper will provide 5 days of sour water storage volume to accommodate scheduled and unscheduled shutdowns.

3.8.7 POLLUTION CONTROL PROGRAM

As indicated in Subsections 3.8.5 and 3.8.6, extensive facilities will be provided to minimize the emission of potential pollutants. These facilities will include:

- Low-Btu gas cleaning by water wash, followed by the Stretford system to remove ammonia and sulfur in the fuel
- Sour water stripping to reduce ammonia and hydrogen sulfide in the process wastewater
- Tail gas treatment to reduce sulfur oxide emissions to the atmosphere
- Amine treatment of fuel gas to reduce the sulfur content
- Treatment and reuse of process wastewater

In addition to the major measures given above, the pollution control program will also include good housekeeping, strict equipment maintenance, and installation of many pollution control systems, including:

- Vapor recovery systems, as required on storage tanks
- Connection of various blowdowns to flares or to vapor recovery systems
- Connection of relief valves and turnaround purge vents to flares for vapor recovery systems in accordance with sound engineering practice
- Installation of pumps and compressors with positive seals

Details of the emission rates and the pollution control plans are discussed in Sections 4.2 and 4.4.

Section 3.9

Section 3.9

SOILS HANDLING

In the construction of surface and mine facilities, large amounts of soil and rock will be excavated and moved. In this section, earth-moving activities of the White River Shale Project are described, applicable regulations reviewed, and compliance methods summarized.

3.9.1 SUMMARY OF EXCAVATION AND DISPOSITION OF EXCESS MATERIAL

During the White River Shale Project, approximately 400 acres on Tracts U-a and U-b will be excavated; this includes approximately 120 acres during Phase II, the single retort operation phase, and 280 acres during Phases III and IV, the commercial operation phases. (Additional information can be found in Table 5.4-1.) Land disturbances and characteristics of materials, including plans for the ultimate disposition of removed material, are described in Section 4.6.

As much excavated material as possible will be used for construction activities. For instance, overburden from the U-b inclined entry will be used in grading the plant site and as fill, in part, for the construction of project impoundments.

The proximity of Southam Canyon to most of the earth-moving construction activities in the process area and mine entries will allow unusable materials to be disposed of in the canyon along with processed shale. Disposal of excess materials in Southam Canyon will eliminate the need

for numerous, separate small landfills and will have no significant effect on processed shale disposal.

A small landfill will be created of materials removed from the six mine ventilation shafts in Tract U-b. This landfill, approximately 100,000 cubic yards covering 2.4 acres, will be rehabilitated using methods described in Section 4.6.

3.9.2 REGULATORY REQUIREMENTS

The Oil Shale Lease stipulates that excavated material and processed shale should be revegetated. Many additional requirements for overburden disposal and disturbed land reclamation appear in laws and regulations requiring that soils handling include measures for erosion control (thereby protecting water quality), slope stabilization, and revegetation.

3.9.3 TOPSOIL STOCKPILES

In the current revegetation plan, topsoil will be obtained as needed from Southam Canyon. The specific amounts of topsoil required for this procedure will be determined during operation of the project. It may be found necessary to stockpile quantities of topsoil for later use; if so, temporary stockpiles will be placed on areas of the finished processed shale fill surface until they are needed. Slopes of these stockpiles will be stabilized to control erosion, but no revegetation efforts will be made.

Section 3.10

Section 3.10

PROCESSED AND RAW SHALE DISPOSITION

3.10.1 INTRODUCTION AND OVERVIEW

After oil shale is processed in retorts and the kerogen is recovered, the remaining processed shale must be disposed of in an environmentally acceptable manner. Disposal will be a major consideration in developing the oil shale lease tracts because, as a result of mining and crushing, the volume of the processed shale will be up to 20 percent greater than the original material mined.

Disposal will be complicated by the present lack of large-scale commercial operations that could suggest proven procedures for handling the processed shale and placing it in a final location. In addition, only preliminary laboratory test data are available on the specific characteristics of processed shale from Tracts U-a and U-b.

In the most probable plan for processed shale disposal, Southam Canyon to the west of the processing area will be used as the disposal site for all project stages. Southam Canyon has the advantages of being on tract, of having sufficient volume to hold the anticipated amount of processed shale, and of having a relatively small drainage area. These characteristics suggest that disposal of processed shale in Southam Canyon will have a lesser overall environmental impact than disposal in alternative sites. This is discussed in Section 7.10.

3.10.2 CHARACTERISTICS OF PROCESSED SHALE

The characteristics of processed shale are determined by three major factors: (1) composition of the raw shale, (2) the nature of the retorting process, and (3) the retorting temperature. Shale processed by a vertical-type retort is a coarse material with a silty, gravel-like, gray-to-black appearance. Shale from a fines-type retort is a fine-grained, easily crumbled, silty black material.

The raw shale samples from U-a and U-b have been processed only with laboratory equipment — neither a vertical-type nor a fines-type retort — but some Colorado shale has been processed by a Paraho vertical-type retort at Anvil Points. Consequently, both types of shale were examined to determine the most probable physical and chemical characteristics of processed shale that will come from Tracts U-a and U-b. It is recognized that actual characteristics of shale retorted at the White River site may differ somewhat from those described here; further analyses will be performed when site-specific shale becomes available in larger quantities.

3.10.2.1 Physical Properties

It is anticipated that the Utah processed shale will display physical properties similar to those of the Colorado shale; the characteristics described here are based on the Woodward-Clyde Consultants tests on Colorado material (Ref. 36). Table 3.10-1 summarizes regular physical properties.

On the basis of the gradation and plasticity tests, the sample shale falls into the silty gravels, gravel-sand-silt mixtures group, as classified by the Unified Soil Classification System.

Table 3.10-1

REGULAR PHYSICAL PROPERTIES OF COLORADO PARAHO PROCESSED SHALE[a]

Gradation (ASTM D422)	
Maximum particle size	2 in.
Clay size (0.005 mm)	2%
Silt and clay size (- No. 200 sieve)	22%
Sand size (No. 200 to No. 4 sieves)	23%
Gravel size (+ No. 4 sieve)	55%[b]
Plasticity (ASTM D423 and D424)	
Liquid limit	—
Plasticity index	nonplastic
Specific gravity (ASTM D854)	
Apparent (all sizes)	2.59[b]
Relative density[c] (ASTM D698)	
Dense (100%)	89.4 lb/ft^3 (d)
Loose (0%)	71.5 lb/ft^3 (d)

Compaction[c] (ASTM D698 and D1557)

	Compactive Effort	Optimum Moisture	Density (Max. at Optimum Moisture)
Low	6,200 ft-lb/ft^3	23.7%	88.0 lb/ft^3
Moderate	12,375 ft-lb/ft^3	22.0%	92.5 lb/ft^3
High	56,250 ft-lb/ft^3	22.0%	98.0 lb/ft^3

Permeability[c] (USBR Earth Manual, E-13)

	Compactive Effort	Permeability at Loading		
		50 psi	100 psi	200 psi
Low	6,200 ft-lb/ft^3	15.5 ft/yr	5.5 ft/yr	1.7 ft/yr
Moderate	12,375 ft-lb/ft^3	7.0 ft/yr	1.4 ft/yr	0.8 ft/yr
High	56,250 ft-lb/ft^3	1.1 ft/yr	0.6 ft/yr	0.08 ft/yr

(a) Sample 1-B taken from Paraho semiworks plant at Anvil Points, Colorado
(b) Average of two values
(c) Minus 1-1/2 inch fraction
(d) Lower numbers have been reported by others on similar materials

(Data Source: Woodward-Clyde Consultants, Inc., Ref. 36)

The apparent specific gravity (permeable voids filled with water) of 2.59 is on the order of values for concrete, sand, and gravel aggregate.

Compaction tests on the minus 1-1/2 inch fraction of the sample showed little gain in density with the addition of moisture up to optimum content. A significant increase in density occurred with increased compactive efforts (from 6,200 to 56,250 foot pounds per cubic foot). The low value is comparable to that achieved by tractor spreading or light rolling; the high value is the heaviest type of compaction normally obtainable and is used for high-loaded highway and airport subgrades. The processed shale took water readily and appeared to be porous. A temperature rise was noted after water was added, indicating that some hydration (and possibly some cementation) was taking place. Water retention capacities of processed shale are discussed further in Section 4.6.

Permeability (the ease with which water will flow through the material) of processed shale usually reflects its structure. To estimate surface runoff, seepage, and leachate potentials, the effects of compaction or loading on permeability must be known. Permeability measurements show that a relatively impervious material (permeability of less than 1 foot per year) can be produced from the Paraho-processed shale at the density achieved by heavy compaction or at the intermediate density with heavy loadings. The U-a and U-b shale is expected to exhibit somewhat lower permeability under similar compaction because of the presence of more fines.

3.10.2.2 Chemical Properties

The chemical composition of processed shale and its relationship to the White River Shale Project is discussed in Section 4.6 and in the reports prepared by Woodward-Clyde Consultants (Ref. 36).

3.10.3 SOUTHAM CANYON – THE DISPOSAL AREA

Southam Canyon, just to the west of the processing area, as shown in Figure 3.10-1, is the preferred disposal area for shale processed in all stages of the White River Shale Project. Factors relevant to using Southam Canyon as a processed shale disposal area are summarized below.

- There is sufficient volume on tract to hold the anticipated amount of processed shale from the entire White River Shale Project
- The low average rainfall in the area of Tracts U-a and U-b (8 to 10 inches per year) will normally result in a low level of surface drainage from Southam Canyon. Records indicate that the 100-year, 10-day precipitation for the northeast section of Utah where Tracts U-a and U-b are located is less than 4 inches
- Ecological considerations
- The geologic, hydrologic, and meteorologic characteristics of the area are described in Section 2 of this report

One obvious characteristic of Southam Canyon is its extremely irregular topography. While there is a general pattern of a depression within an east and west ridge system and a general downslope from south to north, substantial ridges and projections break up the entire canyon into a series of internal canyons. A section drawing through Tract U-a is shown in Figure 3.10-2. During single retort operation of the White River Shale Project, this characteristic will be useful because the disposal areas can be isolated in side canyons. However, during commercial operation, the rough topography of the canyon rather severely limits the variety of procedures that can be used for handling and placing the processed shale, as discussed in the alternatives presented in Section 7.10.

3.10.4 PHASE II – SINGLE RETORT OPERATION

In the single retort operation, at 10,000 tons per calendar day (TPCD) of shale mined and processed, the unit will produce approximately 1,300 TPCD of raw shale fines and 5,900 TPCD of processed shale.

3.10.4.1 Fill Plan

The processed shale from Phase II of the White River Shale Project will be placed in a side canyon on the eastern ridge of Southam Canyon, as shown in Figure 3.10-3.

Processed shale will be brought from the retorting area by conveyor generally southward to the loop road shown in Figure 3.10-3 (this road is shown in greater detail on the layout map in Figure 3.4-3). The conveyor will deliver the processed shale to a truck loading bin, and from there, trucks will move it to the disposal area. Filling will advance in a northwesterly direction from the indicated starting point, with a 5 percent slope on the advancing edge to permit the bottom-dump trucks to descend and ascend the slope, dumping the material in layers and compacting it with their wheels. Bulldozers will complete the shaping of the pile. At completion, the top surface of the pile will be at an elevation of 5,500 feet, the southwest side of the pile will have a 4:1 (horizontal:vertical) slope, and the other sides will blend into the topography.

If the mining operation never proceeds beyond the single retort phase, the processed shale will be left ready for revegetation in a small compact pile in this side canyon. If operations proceed into the commercial phase, various sections of this initial pile will provide a large-scale station (from 20 to 30 acres) for development of suitable revegetation procedures, will act as a valuable terminal for the covered processed shale conveyors that will come from the retorts in the commercial phase, and will serve as a staging area for the larger disposal operation.

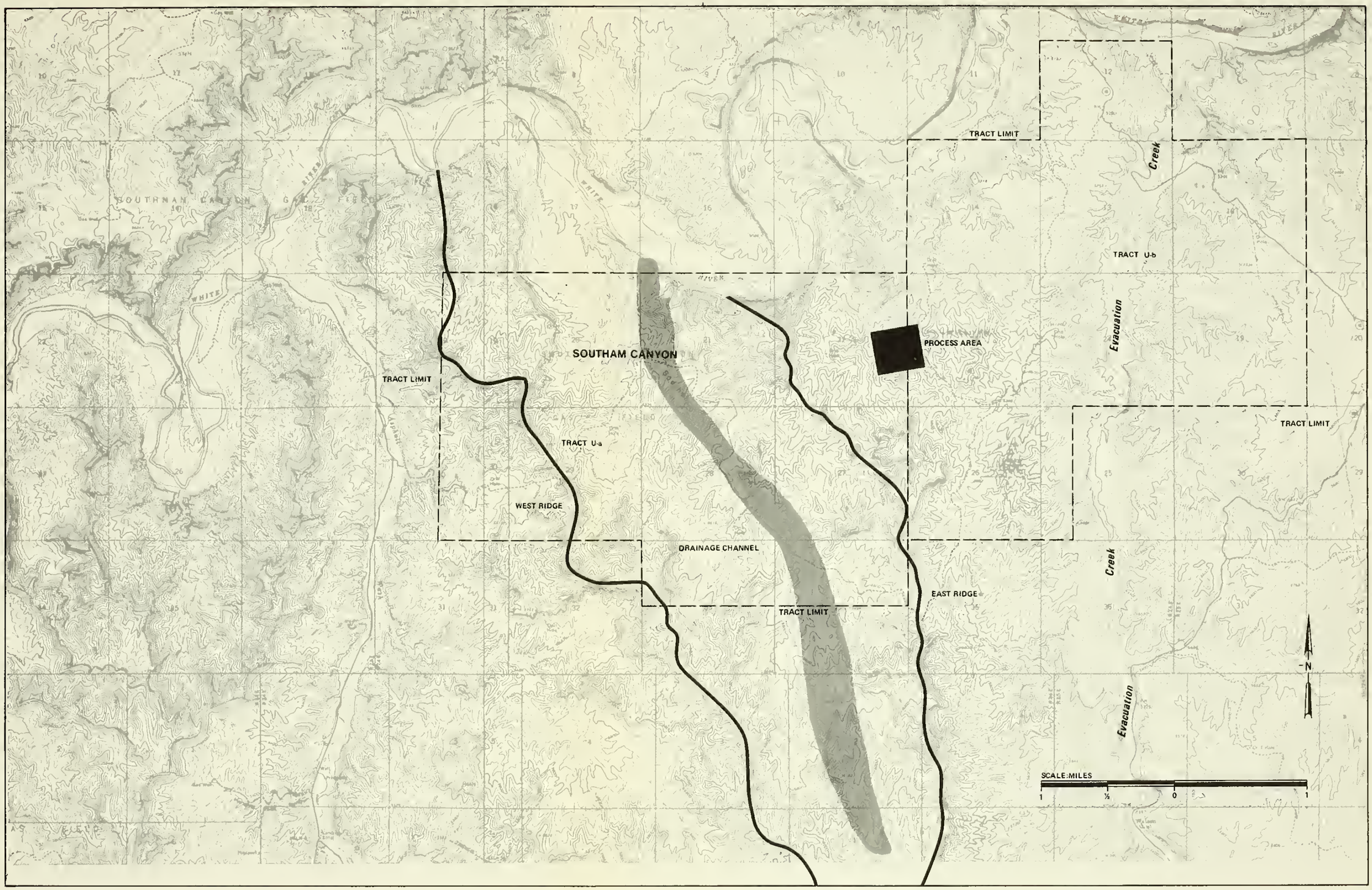


Figure 3.10-1. Southam Canyon – Processed Shale Disposal Area

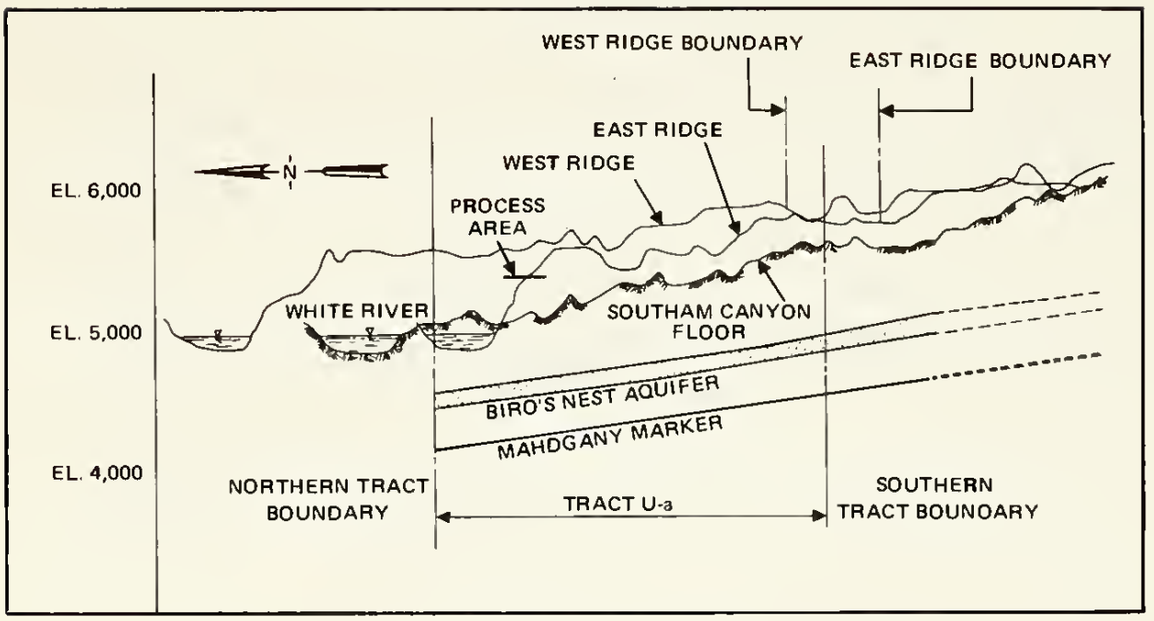


Figure 3.10-2. Section Drawing of Tract U-a

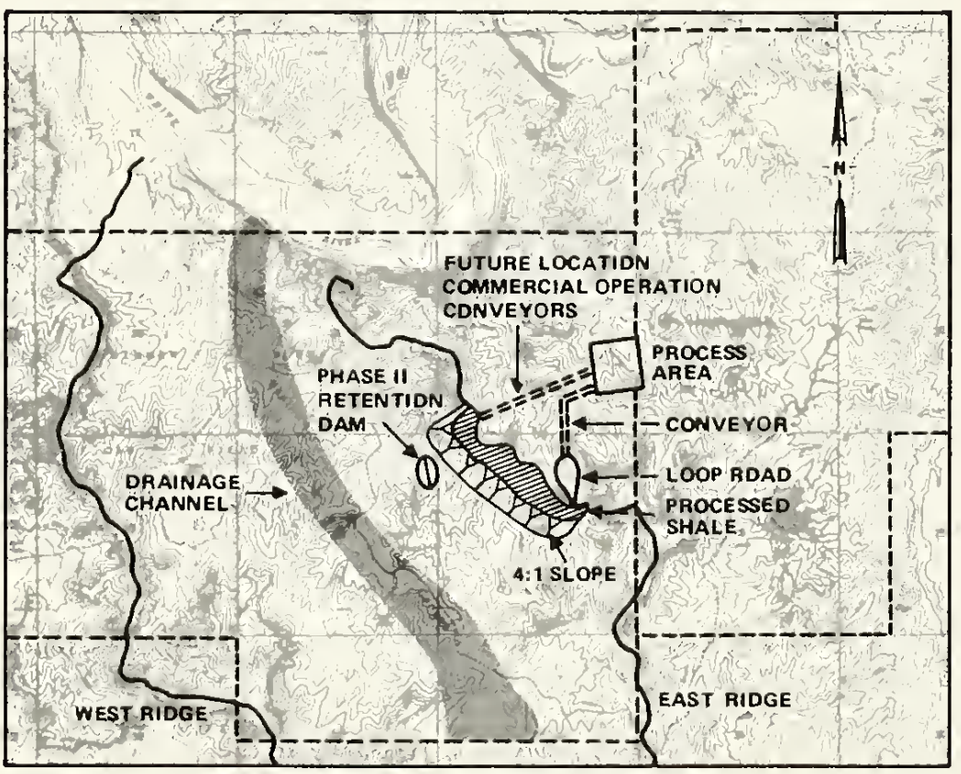


Figure 3.10-3. Phase II Fill Plan

3.10.4.2 Water Control and Management

Surface Runoff. A small dam will be constructed west of this processed shale pile to control runoff from the pile. Its construction will maximize the use of local materials, and it will provide sufficient storage to contain runoff from the 100-year storm in a drainage area of approximately 500 acres. Small berms may be necessary in the northeast part of the disposal area to prevent contaminated water from entering the unprotected drainage basin to the east. A significant portion (approximately 90 percent) of the natural drainage of Southam Canyon will not be interrupted. Storm runoff that has not been in contact with the processed shale will continue to flow directly to the White River.

The dam will be abandoned when the project enters the commercial phase and will eventually be covered by future placement of processed shale. If the project does not continue into the commercial operation phase, the dam catchment will contain any leachate and storm runoff. The resulting drainage impoundment will then function as an evaporation pond.

When the processed shale pile has reached final elevation, the surface will be shaped or sculptured in a pattern similar to that of contour farming, as shown in Figure 3.10-4. There is a dual purpose in this program: water runoff will be prevented or minimized, and water captured will be beneficial to plant growth both during and subsequent to the revegetation period. This minimizing of runoff from the surface will keep the volume trapped by the dam to a low level. A more detailed description of surface preparation and revegetation plans appears in Section 4.6.

Impounded runoff water from the processed shale pile will generally be poor in quality because of high salt content. The water will be unsuitable for either irrigation or leaching but will be very useful at the disposal site for supplemental dust control and compaction, as discussed more fully in Section 3.15.

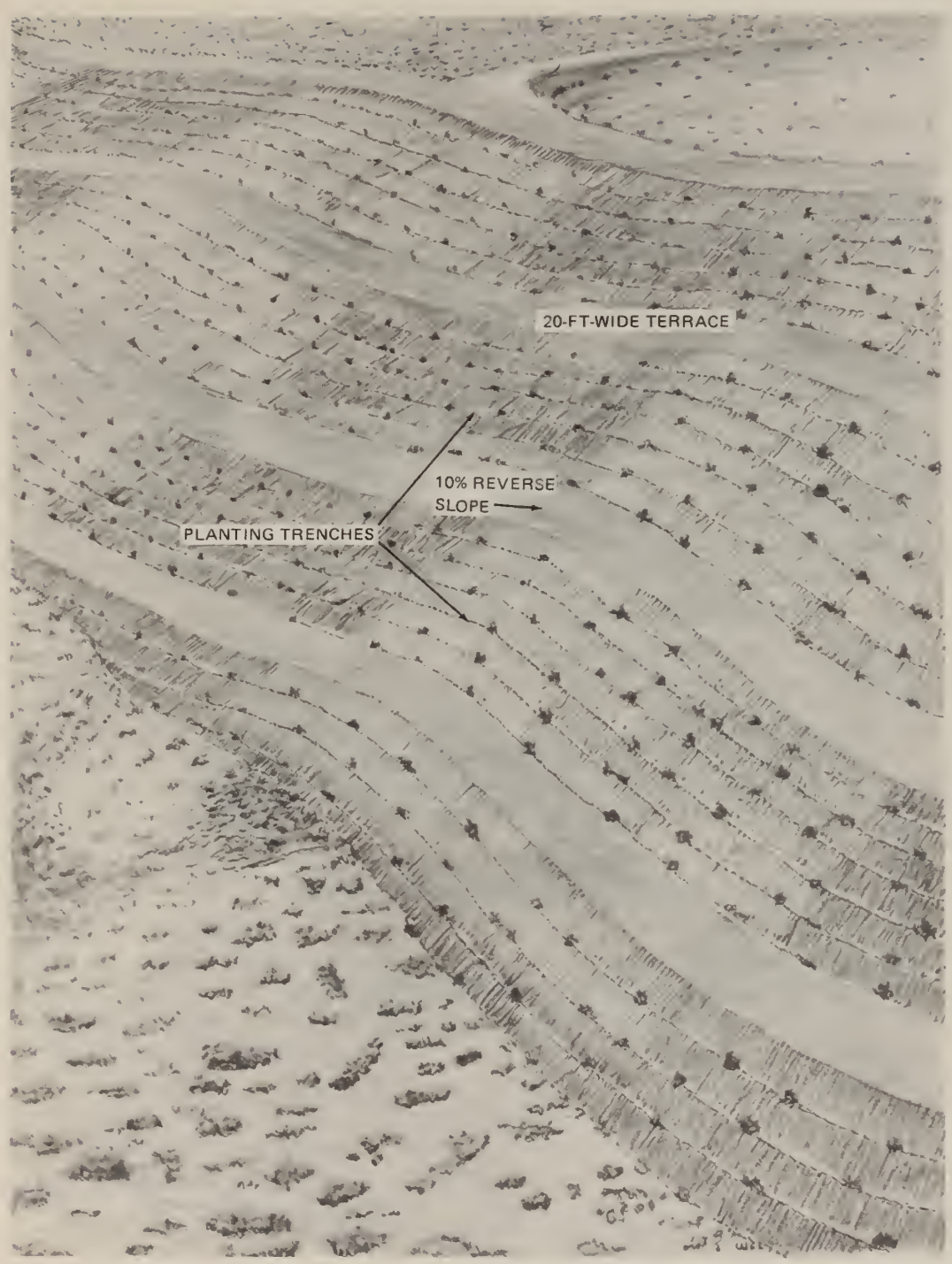


Figure 3.10-4. Contouring for Revegetation Program

Water Percolation. A review of available data (see Sections 2.2 and 2.3, and Ref. 7) suggests that the Bird's Nest Aquifer is unlikely to become contaminated with leachate from the processed shale materials. Downward percolation of leachate will be reduced by the compaction of the processed shale, first under the pressure of truck tires, and then by the weight of the overlying material placed as the operation proceeds.

3.10.4.3 Dust Control

All of the operations involved in transporting processed shale from the retorts to the final placement point will generate dust. Dust control plans are detailed in Part 4 and include the following:

- The processed shale will be moisturized as it leaves the retorts as a first step to control dust and to make the processed shale easier to compact.
- The entire length of the conveyor will be enclosed to prevent dust emission.
- At the loadout bins, a dust-suppression system using water mixed with a chemical wetting agent will minimize dust as the shale is discharged from the conveyor into the bin, and from the bin into the hauling trucks.
- Truck hauling routes will be continuously maintained using conventional road wetting and chemical stabilization techniques.
- As the processed shale is spread and compacted, water will be sprayed on it to stabilize the surface. A chemical wetting agent may be used if it proves effective in reducing water consumption or improving surface stability.

3.10.4.4 Revegetation

After the processed shale pile has reached final elevation, the surface will be contoured as mention in Subsection 3.10.4.2, and plants will be placed in the depressions in earth-filled trenches (Ref. 38). This program is more fully described in Section 4.6. The top of the processed shale pile produced during the single retort operation, an area of

approximately 20 to 30 acres, will serve essentially as a pilot revegetation station. The information and methods developed during the current ongoing research program at Utah State University will be used to develop final plans for the commercial operation phase.

3.10.5 PHASES III AND IV – COMMERCIAL OPERATION

The commercial operation phases of WRSP will benefit significantly from lessons learned during the single retort phase. For this reason, the single retort operation must be viewed as a period for examining closely the many complexities of the project and for making a whole series of judgments about the detailed engineering approaches to be used during the commercial operation stage. It is expected that new information about both processed shale and revegetation will emerge from the Phase II activities and will have a significant impact on the details of final design and operation. Therefore, it should be clearly understood that the plans for processed shale disposal described in the following paragraphs are the best thinking available today, but will be improved and augmented as information that will allow increased environmental effectiveness becomes available.

3.10.5.1 Fill Plan

The commercial operation phase fill plan will be dictated by several important factors. Among them are the following:

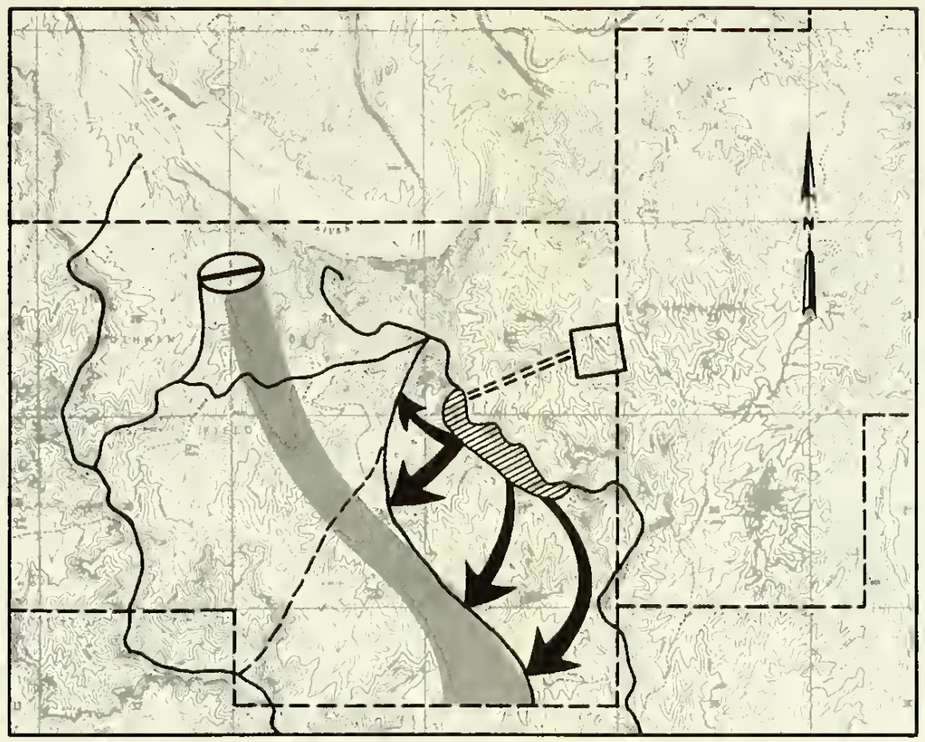
- Very early in the commercial phase, a retention dam will be built at the north end of Southam Canyon across the main drainage channel to control runoff contaminated by processed shale.
- Processed shale will be placed in Southam Canyon in a pattern that will leave the main central drainage channel open as long as possible.
- The work of placing processed shale in Southam Canyon must proceed at a number of locations simultaneously in order to avoid significant traffic congestion.

- The processed shale will be piled in Southam Canyon in such a configuration as to generate areas for revegetation at early and reasonably uniformly spaced successive stages.

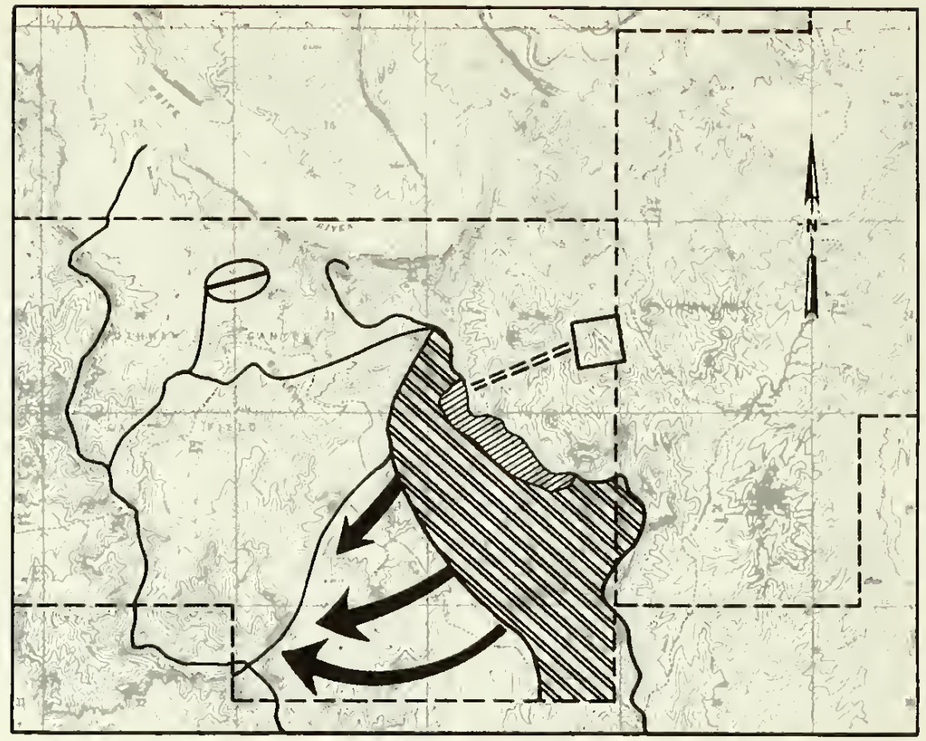
On the basis of these factors, the most probable fill plan was developed and is shown in Figure 3.10-5. During the first-train operation, at 50,000 barrels per calendar day of crude shale oil output, the processed shale will be conveyed to the area of the single retort operation phase pile and will then be placed in a fanlike pattern toward the north, west, and south. This program will prepare a large base for expanded operations when the second train is added. Care must be exercised to prevent the pile from interfering with the drainage pattern down the main channel of Southam Canyon.

As commercial operations move into the two-train stage at 100,000 barrels per calendar day, the principal direction of building the processed shale pile will be along the eastern half of Southam Canyon toward the south. To avoid truck congestion, the pile will be built from several different locations rather than at a single front. As was done previously, the material will be moved by a combination of conveyors and trucks, but the conveyors will be brought as close as possible to the point of processed shale placement because movement by conveyor is less disturbing to the environment and less costly than trucking.

Figure 3.10-5 shows the planned fill pattern at various times during the life of the project. As the processed shale fill nears the southern tract boundary, the direction of the activity will shift to the west until the southern end of Southam Canyon within the tract has been filled. During all of the work up to this time, the levels of processed shale piles left behind will be final levels, with surface sculpturing and contouring proceeding in accord with the plan described for Phase II. This early completion will permit revegetation to begin at the earliest possible time.



YEAR 5 (APPROXIMATELY)



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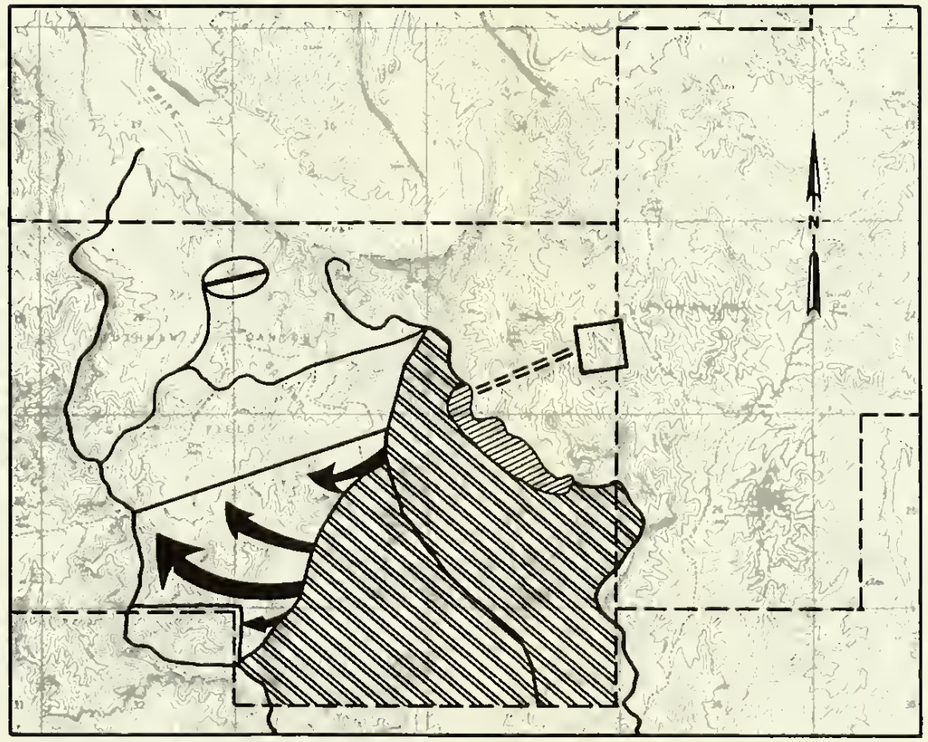

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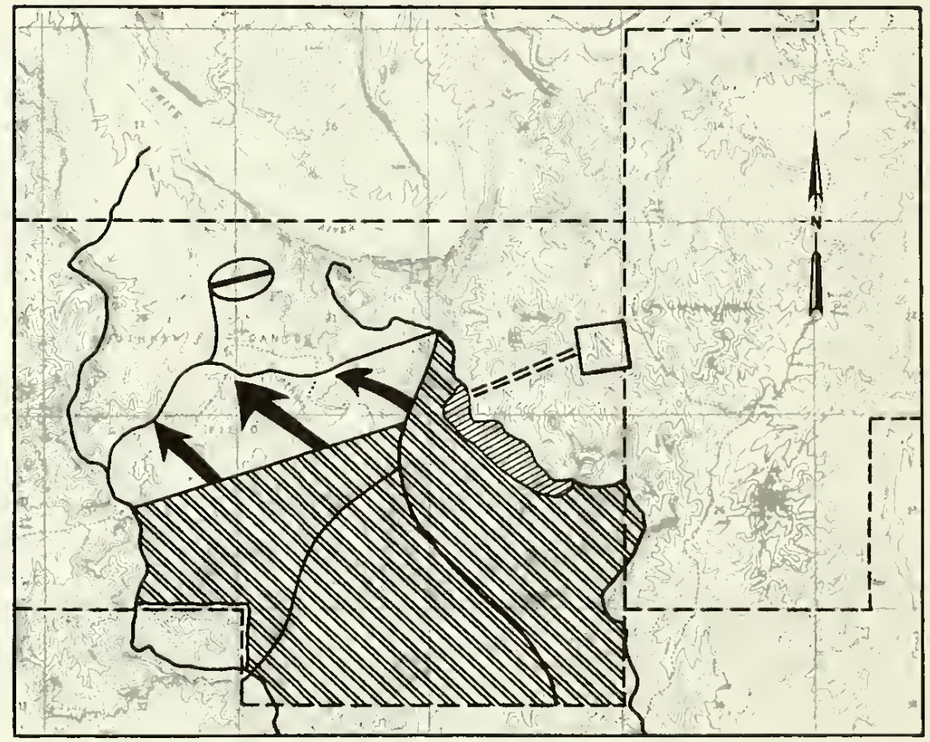

YEAR 20 (APPROXIMATELY)

Figure 3.10-5. Fill Plans for Phases III and IV

In later years, the processed shale will be placed in a pattern moving northward, filling the canyon from the piles on the east across to the western ridge. Final contouring and final levels will be established as the pile proceeds northward. Toward the end of the period of commercial operation, the processed shale pile will reach its intended northern boundary and will be completed with a 4:1 slope suitable for final revegetation (see artist's conception, Figure 3.10-6).

3.10.5.2 Water Control and Management

Early during Phase III, a dam will be constructed near the mouth of Southam Canyon to control contaminated runoff from processed shale. This retention dam will be an embankment-type structure that maximizes the use of local materials, and it will include cutoff and foundation treatment necessary to prevent and control seepage. It will be designed to ensure safety of the structure and to prevent contaminants from entering the White River. The location of the dam is shown in Figure 3.10-5.

The water control plan promotes a reduction in drainage area by the placement of processed shale in Southam Canyon, thus reducing the quantity of contamined runoff. The contouring and planting procedures will create many small catchment basins on top of the processed shale pile, and these will catch and retain precipitation.

As was true in the single retort operation phase, water that comes in contact with the processed shale will be contaminated by soluble salts. This water, however, can be used for dust suppression at the disposal site. Information about the overall water balance of the White River Shale Project appears in Section 3.15.

Other features of water control and management will be patterned on the Phase II operation, adapted and altered as experience dictates. As designed, this sytem is believed adequate to meet all credible conditions.

3.10.5.3 Dust Control

Dust control techniques described for Phase II will be continued during the commercial operation but at a greater number of working fronts. The same methods of control offer excellent promise of holding environmental contamination to acceptable levels (see Subsection 3.10.4.3 and Section 4.2).

3.10.5.4 Revegetation

At this time, the White River Shale Project can offer only conceptual ideas as to how the revegetation problem will finally be solved. Additional data are forthcoming in the USU revegetation study report. However, the basic approach of arranging a sculptured and contoured surface that will result in maximum water retention appears to be a key element of the revegetation program. It is likely that experience gained during the single retort operation phase and in the early commercial operation will permit a revegetation program to proceed in an orderly and successful fashion throughout the life of the White River Shale Project.

3.10.6 RAW SHALE FINES DISPOSITION

During the single retort operation phase, the raw shale fines resulting from the crushing and screening of material mined at that time may be disposed of by combining it with processed shale and placing it in Southam Canyon. It is felt that the environmental problems associated with stockpiling a raw shale fines pile and recovering it for processing during the commercial operation would warrant the minor resource loss. Further discussion of this subject appears in Sections 4.3 and 7.10.

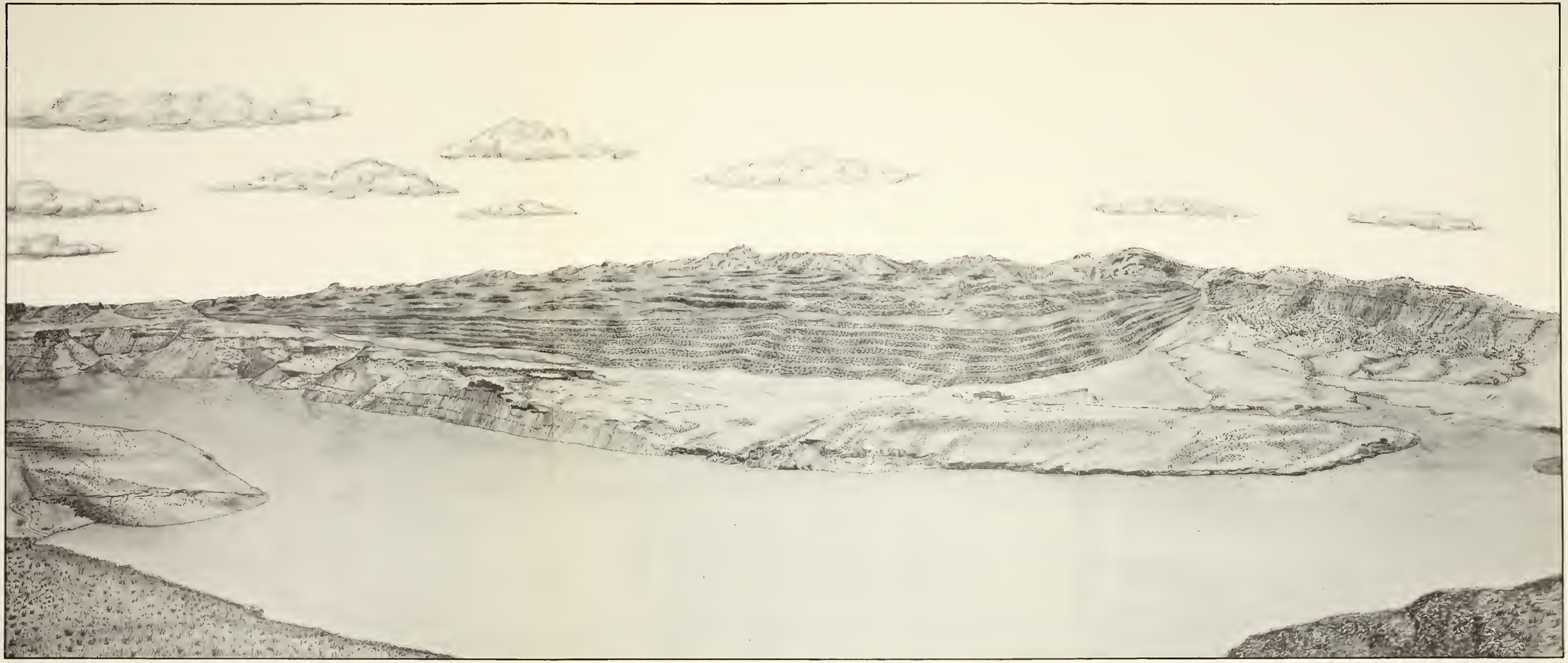

Figure 3.10-6. Artist's Conception of Processed Shale Pile in Later Years of Project (looking southeast across reservoir on White River)

Section 3.11

Section 3.11

SOLID WASTE DISPOSAL

This section briefly describes solid waste sources and types, their collection, and their disposal for various phases of the White River Shale Project construction and operation. Overburden disposal and processed shale disposal are discussed in Sections 3.9 and 3.10, respectively. Figure 3.11-1 shows the overall scheme for solid waste disposal during the major project phases.

3.11.1 SOLID WASTE SOURCES AND TYPES

The bulk of solid waste from construction activities during Phase II, the single retort operation phase, and Phases III and IV, the commercial operation phases, will be inert construction debris totalling about 30,000 tons. Lesser quantities of other waste, including general trash and garbage, will also be produced.

During single retort operation, raw shale dust will be generated by the primary and secondary crushing and by the retort feeding system. Processed shale dust will be created by the retort discharge system. The Stretford unit will generate about 2.3 tons per day of low-grade elemental sulfur. Other miscellaneous waste includes general plant trash and garbage, digested biological sludge, and waste materials from shop and maintenance activities.

At full commercial plant operation (Phase IV), raw shale dust from feed preparation and handling will total about 170 tons per day, and raw and processed shale dust generated by retorting operations will total about 400 tons per day. An average of 1,700 tons of catalyst will be exhausted

each year in the upgrading units. There will also be approximately 700 tons per year of waste fire bricks and fines-type heat carriers. Diatomaceous earth and activated carbon filter cake materials will total about 100 tons per year, and about 87 tons per day of elemental sulfur will be generated by the Stretford unit. Miscellaneous wastes consisting of water, wastewater sludge, and general plant trash and garbage will also be produced throughout the commercial operation phase. Proportionately less waste will be generated during Phase III, the first-train commercial operation phase, than during Phase IV, the two-train commercial operation phase.

3.11.2 WASTE COLLECTION

During all construction phases, waste construction materials will be deposited in large bulk containers and dumpster bins strategically located throughout construction areas. Smaller container bins (with hinged covers) will also be used to collect general trash and employee garbage. Waste oils, rags, and other oily or chemically contaminated material will be collected in safe, fireproof containers.

In the course of commercial plant operation, spent catalysts and spent filter cake materials will be unloaded periodically into airtight, transportable containers. Special handling procedures will be used to assure the safety of this operation.

Miscellaneous waste will be collected and handled in the same way in both single retort and commercial operation phases. Trash and garbage will be deposited in covered bins. Skimmed oils from wastewater facilities will be pumped into the slop oil tanks and later recovered. Wastewater treatment sludge will be digested and stored in drying beds for later use in soil conditioning; it will also be used to moisturize processed shale.

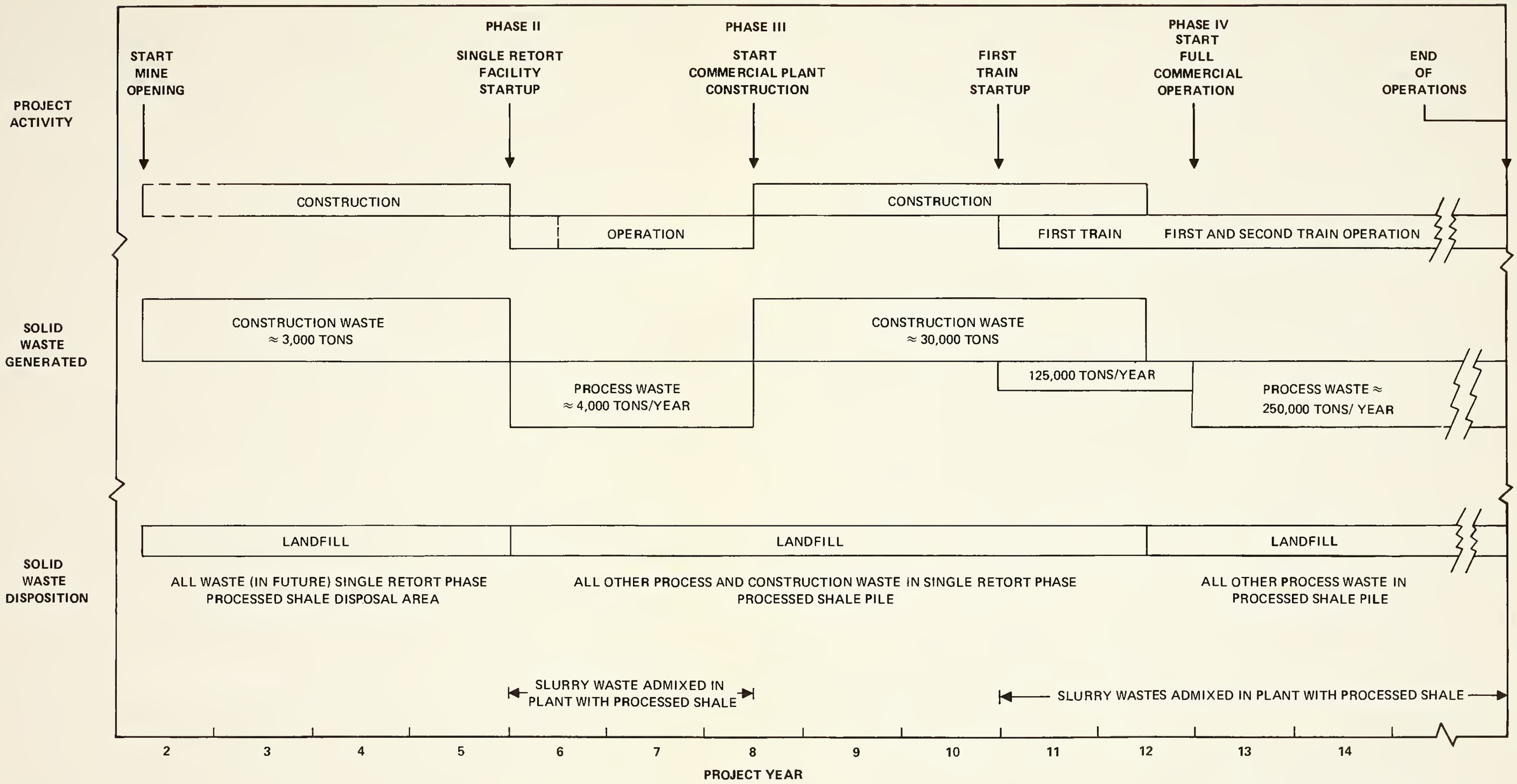

Figure 3.11-1. Solid Waste Disposal Schematic

Slurried dust from the various dust scrubber systems will be injected into the processed shale moisturizers. (Although it would be possible to reclaim the slurried dust and feed it to the fines-type retort, this material is extremely fine, and most of it would blow right through the retort, ending up once again in the scrubber system.) Elemental sulfur from the Stretford unit will also be slurried and added to the processed shale. These slurry wastes, which are mixed with the processed shale, will be transported by conveyor to the processed shale disposal site.

During both construction and operation phases, all solid waste, except the above slurry wastes and some catalysts, will be transported by truck and deposited in the processed shale disposal area in Southam Canyon. Collection frequency and equipment will be appropriate for the quantities and types of waste being generated. Special transporters may be needed for handling spent catalysts.

3.11.3 WASTE DISPOSAL

All of the solid waste will be landfilled in the processed shale disposal area, either mixed directly with processed shale at the plant or separately disposed of in a landfill and covered with processed shale later.

Solid waste landfill activities will be confined to specific sites to facilitate ultimate coverage by a large quantity of processed shale. Landfill sites will be developed sequentially, but only one site will be active at any time.

During Phase II construction, the landfill site will be located in one corner of the processed shale disposal area (see Figure 3.10-3). Overburden from construction may be used for temporary cover material. (Processed shale will not be available at this time.) Waste will be discharged at a small working face, using an area landfill method, and will be spread, compacted, and covered.

During early Phase II operation, solid waste will continue to be deposited in this landfill until the deposits of processed shale reach the site. A new site located in the shale disposal area will be used for solid waste disposal throughout the remaining Phase II operation period.

As Phase III construction begins, a new solid waste landfill site will be located in the western side of Southam Canyon. During Phase III operation, the processed shale embankment will eventually cover this solid waste landfill. As the processed shale disposal pile progresses, new solid waste disposal sites will be created, as needed, and the solid waste landfills will become layered in the process shale.

The same landfill procedures (spread, compact, and cover) will be used throughout Phases III and IV. Revegetation of completed sections will be carried out in conjunction with the processed shale revegetation activities.

Section 4.3 describes the solid waste landfill procedures in more detail.

Section 3.12

Section 3.12

Section 3.12

Section 3.12

SUPPORT FACILITIES AND REQUIREMENTS

Utilities supplies and facilities will be required at various levels throughout the development of the project. The facilities and requirements include electric power, water for steam generation and cooling service, water for processed shale wetting, and communications services.

Fuel required for process heating, steam generation, electric power generation, and miscellaneous uses will be provided by burning low-Btu by-product gases, supplemented by upgraded shale oil product as required, and alternatively by importing electric power.

Communications will be provided by a complete internal telephone system, a tie-in to outside public telephone facilities, and high-frequency radio communications gear, as expedient.

The general requirements and plans for these various utilities and services are described in the following subsections.

3.12.1 ELECTRIC POWER LOAD

The power requirements of the construction and operating stages of each phase of the project are described in the following paragraphs. From start of Phase II operation through Phase IV construction, there will be varying degrees of overlap.

3.12.1.1 Phase II Construction Power

The initial electric power requirements for construction loads are estimated at about 3 megawatts total: 1 megawatt at the plant site and 2 megawatts at a camp and trailer residence area. This power can be supplied by bringing a transmission line from an existing substation at Bonanza to the jobsite. However, there is little if any cost advantage in installing a temporary 3-megawatt supply that would be followed almost immediately by the installation of the 13-megawatt system required for the single retort operation phase, and, consequently, the larger system will be built. If it is not completed in time for construction use, small combustion turbine alternators can be rented for temporary use.

3.12.1.2 Phase II Operating Power

The Phase II installation with a single retort will have the following electrical loads during operation:

	Normal	Peak
Mining	5,400 kW	7,280 kW
Conveying and secondary crushing	1,070	1,070
Processing	4,590	4,590
Cooling tower, utility plant, and offsite	420	680
Total	11,480 kW	13,620 kW

The Bonanza substation is part of the Moon Lake Electric Association, Inc. distribution system. Because the present capacity of this system will not sustain the added load, modifications will be made and heavier lines will be brought into Bonanza from Vernal via existing poles. New switchgear will be provided as needed. The maximum potential capacity of the expanded system will be approximately 15 megawatts.

3.12.1.3 Phase III and IV Construction Power

Power requirements for Phase III and IV construction activities are estimated at 13 megawatts: 3 megawatts supplied to the jobsite and 10 megawatts to the construction camp and residential area. It may be necessary to supply this load (as well as the load for the Phase II operation) before the existing line from Vernal to Bonanza can be raised to the required level. (While the expanded commercial plant may have a much larger supply system as well as an onsite electric power generating station, these facilities cannot be completed in time to furnish Phase III construction power.) In such an event, the required power will be supplied by combustion gas turbine alternators and by the plant's standby diesel electric generators. The Phase II plant will have a 1-megawatt diesel generator. A second similar generator will be installed as early as possible during Phase III construction. Additional power will be obtained for this construction period from three 5-megawatt gas turbine generators, preferably rented only for the time required.

3.12.1.4 Phases III and IV Operating Power

The final process plant will have excess low-Btu product gas sufficient to generate about 135 megawatts of electric power via fired steam boilers and steam-turbine-driven alternators. In addition, enough of the upgraded shale oil product will be burned in plant boilers to provide an incremental steam turbine power of about 65 megawatts. The end use for this power is shown below:

Mining, crushing, and conveying	56 MW
Process	129 MW
Offsites	16 MW
Total	201 MW

Power will be generated at 13.8 kilovolts, raised to 69 kilovolts via a transformer station, and distributed to the process plant, utilities, mine, and conveyors at that level. Local transformer stations will lower this transmission system level to 2300, 440, 220, and 110 volts, as appropriate.

3.12.2 ELECTRIC POWER SUPPLY

Other than the relatively small loads noted earlier, the proposed plant will not use outside electric power. Alternatives of relying totally on outside power or of using a combined-cycle system are described in Section 7.12 of this DDP.

A mine power load of approximately 55 megawatts will be transmitted about 2,000 feet at 69 kilovolts and reduced at a transformer station to 13.8 kilovolts. The power in the mine for machinery, primary crushing, and conveying rock to the surface will be at 13.8 kilovolts. The power used for surface fans will also be at 13.8 kilovolts.

There will be a 5-megawatt, 13.8-kilovolt water pumping station on the White River about 6,000 feet from the generating plant.

A load of 12 megawatts will be supplied via a 69-kilovolt power line to run the processed shale conveyors. This line will be about 8,000 feet long and will feed four substations at which the level will be reduced to 13.8 kilovolts.

3.12.3 STEAM REQUIREMENTS

The process plant requires steam for various heating loads, for chemical consumption to produce hydrogen, and to power turbines for certain pumps and compressors in critical services.

3.12.3.1 Process and Offsite Use

The cooling of hot process streams will produce a considerable amount of steam. This steam will be available at three pressure levels: 600 psig, 150 psig, and 50 psig. Part of the 600-psig steam will be superheated, but the balance will be saturated. When the plant is in normal design operation, it will provide enough steam for the process heat loads, for hydrogen production, and to supply part of the turbine-driver requirements.

There will be an additional limited steam requirement for process equipment drives, and a much larger requirement for electric power in the mine and in feed shale crushing and conveying, process plant, and offsite uses. The offsite uses will include tank heating, processed shale conveying, lighting, heating, and ventilation. In the commercial plant design, electric power will be produced by generating steam in boilers, expanding it through turbines, and exhausting it at vacuum condition into air-cooled condensers.

Steam generated for these turbine-drive alternators will be delivered at 1,500 psig and 900°F. Under these conditions, and with the generator turbines exhausting at about 4 psia, approximately 2,300,000 pounds per hour of steam will be required. The turbines will be of extraction type, and some steam will be withdrawn at 600 psig to supplement the steam from the 600-psig process steam generators.

3.12.3.2 Equipment Drivers

Mining, crushing, and conveying operations will require enough electric power to produce 71,200 brake horsepower output from the various drive motors in those systems. Process drivers, cooling tower fans and water-circulating pumps, and offsite drivers will have a shaft brake horsepower output of 216,000, thus the total shaft horsepower required will be 287,200. Some 45,000 horsepower of this total will be carried by

steam turbines, leaving a net load of 242,000 horsepower to be supplied by electric motors. This load, plus some power plant accessory loads, will require the generation of slightly more than 200 megawatts of electric power.

A considerable amount of low-Btu gas will be produced with a total heating value of 2,555 million Btu's per hour high heat value (HHV). This fuel can be fired in a boiler to generate steam for driving turbine alternators. Some steam will be required to drive boiler feedwater pumps and steam condensate fans. The net increment of power so generated will be about 135 megawatts.

Power to supplement the low-Btu gas output will be obtained by burning enough of the upgraded shale oil product to produce the required additional 65 megawatts.

3.12.4 BOILER PLANT

3.12.4.1 Boilers

The power plant will have four industrial-type steam boilers of 800,000 pounds per hour generating capacity each. These boilers will be designed for 1,800 psig maximum pressure and will deliver their steam at the superheated outlets at 1,500 psig and 900°F. One boiler will be a spare.

3.12.4.2 Feedwater Pumps

Feedwater pumps will be provided for the process steam generators and the main power boilers. The following process boiler feedwater pumps are included in the plant design:

- 1 pump, plus spare, both steam turbine drive, capacity 1,000 gpm, 800 psi differential, for 600 psig steam generating equipment

- 1 pump, plus spare, both steam turbine drive, capacity 1,000 gpm, 250 psig differential, for 150 psig and 50 psig steam systems

Boiler feedwater pumps for the main boilers will be in separate sets, pump and spare, for each boiler. The pumps will be 2,400 gpm, 1,900 psi differential each, with steam turbine drive.

3.12.4.3 Feedwater Treating

A boiler feedwater deaerator will be required. The feed to this deaerator will be condensate makeup boiler feedwater and 50-psig steam. Operating conditions will be 10 psig and 240°F. A feedwater makeup treating system of full demineralization type for 1,000 gpm will be required.

3.12.4.4 Boiler Blowdown

Boiler blowdown for power plant boilers will include continuous skimming of the steam drums at the water-steam interface and intermittent blowdown of the lower drums.

3.12.5 FUEL REQUIREMENTS

Excess low-Btu fuel gas product will be used as boiler fuel. This fuel has a total heating value of 2,555 million Btu's per hour. Liquid fuel, the upgraded shale oil product, will also be fired at a rate that will provide an additional heat release of 902 million Btu's per hour.

3.12.6 COOLING TOWER

The process units and power plant require relatively little cooling water. The cooling water tower will have a capacity of 67,000 gpm with water inlet temperature at 115°F, outlet at 85°F, summer dry bulb 90°F, wet bulb 65°F, and approach to wet bulb 20°F.

3.12.7 COOLING WATER PUMPS

Cooling water pumps will comprise three vertical shaft centrifugals of 35,000-gpm capacity with 60-psi differential pressure. Two of these pumps will have 1,500-hp motor drivers, and one will have a 1,600-hp steam turbine driver. The cooling tower will be approximately 300 feet away from the refinery. The cooling water supply and return lines will be 54-inch lines (see Figure 3.15-2).

3.12.8 AIR SYSTEMS

Air for plant utility use will be supplied by two 1,000-scfm reciprocating air compressors with 125-psig discharge pressure. One machine will have electric motor drive, and one will have steam turbine drive.

Instrument air will be provided by individual compressor drier sets at each process unit. Tie-in stations for emergency use of the utility air system will be required.

3.12.9 INTERCONNECTING LINES

The process units and offsites will be similar to those of a petroleum refinery of similar size, except for the retorting sections. The retorting sections have large gas and air pipes that are part of the process system and do not constitute interconnecting lines. The vertical-type retort section will have product gas headers running from the retort section mid-area to a power plant by way of a gas treating plant.

Other gas lines will run to the process heaters. Product oil from each battery of five retorts will be collected by a pump and conveyed to storage. Other limited interconnecting piping in the retort area will be primarily for utilities.

3.12.10 PRODUCT LOADING

The net hydrocarbon liquid products may be mixed to form a synthetic crude oil and sent via cross-country pipeline to Casper, Wyoming, for transfer to a common carrier.

The proposed 410 tons per day of ammonia will be stored in a refrigerated atmospheric pressure tank and will be shipped by truck. A loading rack with two truck loading stations will be required. Each station will have a loading pump, a loading line heater, meters, and flexible hose connections for loading highway truck trailers. It is tentatively planned to ship the ammonia via highway trucks with a two-trailer arrangement and a total capacity of 40,000 pounds.

Solid sulfur will be produced at a rate of approximately 165 TPD in the proposed plant and will be trucked to a suitable market. Trucks will be loaded by front-end loaders moving the sulfur from outdoor storage on concrete slabs with curbs to serve as solidification pans.

3.12.11 PRODUCT BLENDING

The liquid hydrocarbon products not used as plant or vehicular fuel will be combined into a single refined shale oil mixture for pipeline shipment. No special blending system will be required.

3.12.12 CHEMICAL AND CATALYST HANDLING

Catalysts for hydrotreating and hydrogen manufacture and chemicals required for product treating, water treating, and other purposes will be stored indoors in metal or fiber drums.

Section 3.13

Section 3.13

ANCILLARY FACILITIES AND MAINTENANCE

This section describes those facilities that are not directly involved with the operation of the White River Shale Project, but that are essential to the continuing safe and orderly conduct of the project. All four phases of development of the shale oil operation will require some facilities described in this section. These will be provided when necessary to support activities within each phase of the project.

3.13.1 RELIEF AND BLOWDOWN

3.13.1.1 Retort Gas Venting

Pressure relief to protect the vertical-type retort equipment will be provided by a water seal tank and stack in the gas line between process units and the power plant. Two such vents will be required. The water seal tanks will vent into thermal oxidizers.

The fines-type retorting section of the plant will have three reactor trains served by a single product recovery section. Each reactor section will have a relief valve in the air compressor discharge venting to the atmosphere for overpressure protection. The single recovery section will have a relief valve at the drum venting to the refinery flare system.

3.13.1.2 Upgrading Gas Venting

The oil processing units for the plant will include relief and blowdown systems similar to those used for petroleum refineries. The relief lines

will go to vapor-liquid separators. Two horizontal blowdown drums, 12 feet in diameter and 50 feet long with 50-psig design pressure, are required. The vent lines to the drums will each be about 3,000 feet long and will vary in size from 12 inches at the inlet end to 24 inches at the 1,500-foot point and continue at 24 inches to the separators.

3.13.1.3 Slop Oil Recovery

Three slop oil pumps of the centrifugal steel case type, each 1,000 gpm at 60-psi differential, will return separated liquids to the plant's slop oil tankage. One pump will serve each separator, and the third pump will be piped as a common spare. Two pumps will have 60-hp electric-motor drivers. The common spare pump will have a 60-hp noncondensing steam-turbine driver.

3.13.1.4 Flares and Incinerators

Two smokeless-type vent gas flare stacks will be provided. The stacks will be 36 inches in diameter and 200 feet high; each will have remote electric ignition equipment.

3.13.2 PLANT DRAINAGE

3.13.2.1 Oily Water Sewers

In all phases, the oily water sewer system will collect all contaminated surface drainage from the process areas, as well as oil-bearing waste streams from the process areas. This system will follow standard refinery practices and will be sealed or trapped and vented to prevent travel of hydrocarbon fumes from one process area to another. All vents will be routed to discharge in safe locations.

The oily water sewer system will discharge to a receiving tank in the waste treatment plant. This system will be a buried gravity sewer.

Plant paving will be designed to prevent oily spills from draining across the surface to another plant area.

3.13.2.2 Sanitary Sewers

Sanitary sewers will collect sanitary wastes from all facilities in the main plant area. These wastes will be segregated and routed separately to the treating facilities.

The processed shale disposal facilities will have their own collection system and will not be connected to the plant sanitary sewer system. This system will be the normal, buried gravity sewer system.

3.13.2.3 Storm Sewers

Storm sewers in the plant area will consist primarily of an open-ditch system. Culverts will be built at road crossings, and access will be provided across ditches, as required. In congested areas, underground sewers will be installed but will be run to open ditches. Plant drainage will be arranged so only nonoily surface waters will be drained into this system. Roof drains and parking lot drainage will run into this system.

Basins or small dams will contain tank spillage and drainage water from the tankage area. After each storm, the drainage water retained by the structures will be released to flow to the wastewater holding basin.

3.13.3 TANKAGE

In general, it is planned to locate hydrocarbon tanks on suitable base pads, which will be made by leveling small areas of the rocky surface of the site. There will be no attempt to surround these tanks with conventional fire wall dikes. Rather, the individual pads will be located so that overflows or leaks will drain away into an adjacent catchment basin that will

provide a catchment volume of 150 percent for the particular tank or tanks being thus protected.

The service tankage provided in Phase II, single retort operation, is shown in Table 3.13-1. These tanks will be retained for Phases III and IV, commercial operation, as indicated in the table.

Table 3.13-1

SERVICE TANKAGE

No.	Phase II	Phases III and IV	Nominal Volume, 1,000 Bbls
1	Sour water	Sour water (from sour water stripper)	40
1	Raw water	Recovered oil	25
1	Raw shale oil	Fuel oil	35
1	Fuel oil	Fuel oil	35
1	Diesel fuel	Diesel fuel	35

All tanks will have cone roofs. The raw shale oil and sour water tanks are gas blanketed.

The storage tankage listed in Table 3.13-2 will be added in the commercial production phase.

3.13.4 WATER STORAGE PONDS

3.13.4.1 Freshwater Storage Pond

The on-tract storage pond will provide a water reserve to maintain a constant supply of water during an outage of the reservoir pumping station or pipeline. This volume will provide 3 days' water supply for the

Table 3.13-2

INTERMEDIATE AND PRODUCT STORAGE TANK SUMMARY

No. Tanks	Material	Tank Capacity	Total Capacity	Tank Roof	Gas Blanket	Basis
		1,000 Bbls				
3	Crude shale oil	500	1,500	Cone	Yes	One CSO HTU shutdown for 25 days; all retorts operating normally
5	Refined shale oil	220	1,100	Cone	No	8 days' storage for pipeline
2	Naphtha HTU feed	175	350	Floating	No	10 days' shutdown with both CSO HTU's operating
1	Diesel fuel	35	35	Cone	No	25 days' diesel supply for mine and processed shale disposal
1	Recovered	20	25	Cone	No	
4	Purchased butane	10	40	Spheres	-	10 days' supply for startup of one H_2 plant @ 50% capacity
2	Fuel oil	35	70	Cone	No	5 days' fuel storage
1	HTU sour water	220	220	Cone	Yes	5 days' storage for water accumulation during shutdowns
1	Ammonia	50	50	Insul. & refrig.	-	10 days' storage
2	Liquid nitrogen	65	130 tons	Insul. & refrig.		Stored quantity for regeneration of one CSO HTU
1	Pour point depressant	0.8	1	Cone	No	30 days' supply at 0.025 vol % dosage; this tank is located in the pipeline gas pumping station

maximum capacity of both the plant and the processed shale disposal area. The dam will be approximately 64 feet high and will be built to conform to applicable engineering standards.

3.13.4.2 Wastewater and Storm Runoff Holding Basin

An embankment-type dam will be constructed downstream from the process area early in Phase II, as shown in Figure 3.4-3. This dam will also be built to conform to applicable engineering specifications.

Its storage exceeds the 100-year storm runoff volume from all tributaries during the Phase II stage of the project. Wastewater, storm runoff, and minor oil contaminates will be collected in this basin.

3.13.5 FIRE PREVENTION AND CONTROL PLAN

It is proposed to provide a level of fire protection equivalent to what is defined as highly protected risk by the insurance industry. Protection conforming to this definition will consist of automatic extinguishing and detection systems, engineering safeguards, and fire-fighting water supplies. The protection will be consistent with the needs of all design-basis fires.

The major plant structures and work areas and the type of protection to be provided are as follows:

- Administration Building. Because of the type of function, occupancy, and records storage, fire hazard is considered "light to ordinary." An automatic sprinkler system and installation of fire extinguishers are proposed for protection.
- Cafeteria. Fire hazard is "light," requiring only fire extinguishers.
- Laboratory. The use of solvents and chemicals and their storage and handling increase the hazard category to "ordinary" (Group 2). Automatic sprinklers are proposed for protection.
- Control Room. Fire hazard in the control room is deemed "light." Special protection is proposed only in the cable spreading area, where engineering safeguards may be used. In addition, installation of fire extinguishers is proposed
- Maintenance Shops. Work in the shop ares is considered "ordinary" (Group 2). Hazards arise from painting, carpentry, and machine shop work. Automatic sprinkler protection will be provided throughout, along with fire extinguishers, standpipes, and small hose lines.

- Warehouse. General storage of supplies categorizes this facility as "ordinary" (Group 3). As such, automatic sprinkler protection, standpipes, hoses, and fire extinguishers are proposed.
- Electric Power Generator Building. The hazard category for this facility is classified as "ordinary." However, certain systems and equipment may be considered "extra hazard," depending on use. In this category are generator lube oil systems, which can be protected with water spray, CO_2, or engineering safeguards such as a fire enclosure. Hydrogen-cooled equipment is also in this category. An automatic CO_2 fire extinguishing system is proposed if a hydrogen gas hazard exists. In addition, standpipes, hoses, and fire extinguishers are proposed.

Major processing hazards and protection measures are as follows:

- Shale Pile. Storage of mined shale of the anticipated quality is not expected to be a significant hazard. It is judged to be less than that of coal. Accordingly, storage will be in a segregated area with no special protection.
- Crushing Operations. There is a potential fire hazard associated with this operation. Normal engineering safeguards, such as wet-down and vacuum collection of dust, should be effective for the potential hazard.
- Refining Process. The fire hazard in the processing area is relatively severe and will require the incorporation of engineering safeguards, automatic fire detection systems, automatic fire extinguishing systems, fireproofing, monitors, and other standard petroleum industry techniques for fire protection.
- Tank Storage. Storage of all hydrocarbons is hazardous. Protection will be afforded by spacing, spill control, cooling, and fire extinguishing systems.
- Processed Shale. Handling processed shale is not expected to be a significant fire hazard. The shale will be transported to the disposal area and compacted without any special provisions for fire protection.

- By-Product Hazards. Both the ammonia and sulfur by-products present some fire hazard and will be stored in a segregated area. Ammonia is very stable as a liquid. No special fire protection will be provided except for engineering safeguards of isolation and containment.
- Conveyor Ways. These should not pose a serious hazard.

3.13.6 MEDICAL FACILITIES

3.13.6.1 First Aid

First aid facilities will be furnished at appropriate locations in the process plant, power plant, maintenance areas, mine, and crushing areas.

3.13.6.2 Clinic

A clinic with examination rooms and equipment (including two hospital-type rooms) and office and laboratory space for a physician and two nurses will be provided.

3.13.6.3 Ambulance

The garage facility at the plant will include space for two ambulances. The distance to the nearest extensive hospital facilities (in Vernal) is about 50 miles, and a single vehicle might not be adequate for some emergency situations.

3.13.7 BUILDINGS AND PARKING

Buildings for the process plant are noted in Table 3.13-3.

The construction of these buildings will be fireproof. The administration building, control house, change house, and laboratory will be of modern design with full air conditioning, heating, and ventilating equipment.

Table 3.13-3

BUILDING REQUIREMENTS

Service	Area, ft^2	Remarks
Administration	28,000	Two-story, steel and concrete
Change house	24,000	Steel and concrete
Main shop and warehouse	70,000	Steel and transite
Firehouse and garage	15,000	Steel and transite
Secondary crushing house	42,000	Steel and transite
Control house with offices	20,000	Steel and concrete
Boiler and electric plant	42,000	Steel and transite
Laboratory	20,000	Steel and concrete

The shop building, boiler house and power plant, secondary crushing house, firehouse, and any other buildings can be of steel frame industrial type with metal or plastic sheet sheathing.

Parking facilities for vehicles of staff and visitors will be provided by grading a suitable area.

3.13.8 MOBILE EQUIPMENT

Approximately 15 units of mobile equipment will be required for the process plant.

Section 3.14

Section 3.14

WATER SUPPLY AND FACILITIES

3.14.1 WATER SUPPLY DEVELOPMENT PROGRAM

Supplying water for the development of oil shale in eastern Utah, as well as for other essential uses and purposes, is a matter of obvious importance. This subject has been studied and reported on by Bingham Engineering of Bountiful, Utah, in the report White River Shale Project, Water Supply Alternatives, January 1, 1976 (Ref. 37). The material in Section 3.14-1 has been abstracted from this reference.

3.14.1.1 White River Dam

Alternative sources of water considered are discussed in Section 7.14. The preferred alternative is a dam and reservoir on the White River, with related pumping facilities to deliver water to Tracts U-a and U-b. The project would be a multipurpose development that would provide a firm water supply for oil shale processing on Tracts U-a and U-b and that would have a capacity sufficient to furnish water for additional oil shale development in the area. Releases would be made from the reservoir to develop and maintain a stream fishery below the dam and to provide irrigation water for up to 14,000 acres of land near the mouth of the White River. This land is primarily Ute Indian tribal land claiming water rights under the Winters Doctrine.

The White River Dam will provide an improved fish habitat in both the reservoir and the stream below by reducing sediment loads and the number of damaging flood discharges; however, some wildlife habitat will be

inundated by the reservoir. The development will enchance water-oriented recreation in the area.

3.14.1.2 General Description of the Basin

The White River rises in the White River Plateau in western Colorado and flows west to its confluence with the Green River at Ouray, Utah, about 26 miles south of Vernal, Utah. The White River Plateau is a relatively flat, high-lying area with elevations generally from 10,000 to 11,500 feet. The average annual precipitation in this area is more than 30 inches. The river receives most of its water supply from this area and then runs westward to the desert rangeland of western Colorado and eastern Utah.

The Utah portion of the White River Basin is mostly desert rangeland with elevations near 5,000 feet. This area is semiarid, characterized by low relative humidity and a wide range of daily temperatures. Mean monthly temperatures vary from near 20°F in January to 75°F in July, with daily maximums in the 90's. The mean annual temperature is 48°F.

Precipitation in the Utah portion of the White River Basin averages close to 7 inches in the lower elevations and close to 12 inches in the higher elevations. The May to October pan evaporation is almost 45 inches.

3.14.1.3 White River Hydrology

Records are available over the last 50 years for mean daily, monthly, and annual discharges of the White River near Watson, where the gauging station is located near the bridge where Utah State Road No. 45 crosses the White River. These records indicate that most of the foreseeable diversion requirements can be met on an annual basis provided there is adequate storage in a reservoir to permit regulation of seasonal and daily variations in the river discharge.

A flow chart of the White River showing the streamflow and present depletions is shown in Figure 3.14-1. The major use of water is for irrigation, and nearly 95 percent of the irrigated land is devoted to the production of hay and irrigated pasture. About 41,000 acre-feet of water are presently used in Colorado. About 7,700 acre-feet of water are used in Utah for lands owned primarily by the Ute Indian Tribe.

3.14.1.4 Water Rights

The Colorado River Compact of 1922 divides the waters of the Colorado River into a Lower Division and an Upper Division, with the dividing point at Lees Ferry, Arizona. The compact intended to give the Upper Division half of the river flow at Lees Ferry. However, the Lower Division (Arizona, Nevada, and California) is guaranteed 7.5 million acre-feet annually.

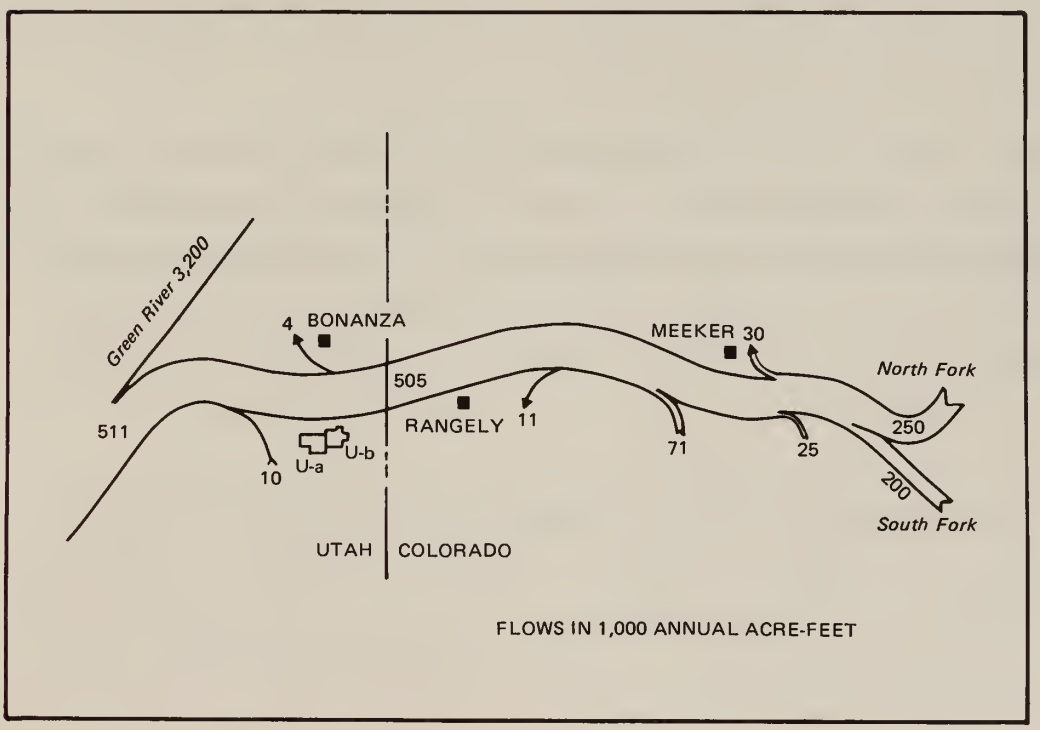

Figure 3.14-1. White River Flow, 1,000 Annual Acre-Feet

Because the historic flows since 1922 are less than 15 million acre-feet, the Upper Division entitlement is something less than 7.5 million, depending on the water supply. The Bureau of Reclamation now estimates the Upper Basin entitlement at 5.8 million acre-feet annually.

The Upper Colorado River Basin Compact of 1948 divides the waters of the Upper Basin on a percentage basis. Utah is entitled to 23 percent and Colorado is entitled to 51.75 of the Upper Division allotment. The remaining percentage goes to Wyoming and New Mexico.

The Upper Basin Compact did not apportion the waters of the White River between Colorado and Utah, nor does the compact appear to offer any procedure to effect an apportionment. Therefore, Colorado and Utah could approve applications from the White River so long as they do not exceed the ceiling provided for in the compact. Negotiations are now under way between Utah and Colorado with respect to a compact for using water from the White River.

It appears that under the principles that govern the allocation of interstate streams, Utah could assert that it is entitled to an equitable share of the flow of the White River (Hinderlider vs La Plata River and Cherry Creek Ditch Co., Ref. 39). Under this concept, each state through which an interstate river flows is entitled to an equitable share of the water from its source.

Neither Colorado nor Utah presently consumes its full entitlement of water under the Upper Colorado River Basin Compact. It is estimated that Utah has 197,000 acre-feet of uncommitted water and that Colorado has approximately 167,000 acre-feet of water that could potentially be available for oil shale development.

It is apparent that, with Colorado having only 167,000 acre-feet of water available for development in the the Upper Basin and with a 500,000 acre-feet annual water supply in the White River at the Colorado-Utah state line, there should be sufficient water remaining in the White River for development in Utah.

The water right for oil shale development in Utah will require a Utah water right. The water right application held by the Utah Board of Water Resources (No. 36979) is by far the largest applied for in the State of Utah.

The Ute Indian Tribe claims water rights sufficient to irrigate about 13,400 acres of reservation land on the White River. The tribe is currently developing about 3,300 acres of this land, and a reservoir on the river to alleviate sediment problems and ice jamming and to control the discharges would enhance the feasibility of increasing this development.

The State of Utah through its state comprehensive water planning program, "The State of Utah Water – 1975," (Ref. 40) recommends that a dam and reservoir be built on the White River to supply water for oil shale development in Utah and for irrigation of Indian lands. It is anticipated that the Utah Board of Water Resources water rights application, along with Ute Indian Tribe Winters Doctrine water rights, would be used for this development.

3.14.1.5 White River Dam Site

The site selected for the dam to be built on the White River is located near the center of Section 17, T10S, R24E, SLB&M. The choice was based on factors such as: the structural competence of the foundation of the dam site, the environmental impact on the inundated area, reservoir efficiency, preliminary cost comparisons, and location with respect to oil shale development.

The proposed dam height of 125 feet was selected to provide an economical structure consistent with topographic conditions. The height can be increased 20 feet if necessary in the future.

3.14.2 PHASE II – SINGLE RETORT OPERATION

3.14.2.1 Facilities

The water supply facilities for Phase II of the White River Shale Project, which are shown in Figure 3.4-1 (Section 3.4), consist of:

- An on-tract well system near the White River
- A 1.9-mile pipeline from the intake
- A storage tank at the terminal end of the pipeline
- A 0.3-mile water pipeline to the plant area

The Phase II water requirements were determined to be approximately as shown in Table 3.14-1

Table 3.14-1

PHASE II WATER REQUIREMENTS

	Water Requirement	
	Average	Annual Average
Process plant	200 gpm	325 acre-feet
Processed shale disposal area	–	–
Total	200 gpm	325 acre-feet
Construction phase	60 gpm	98 acre-feet

3.14.2.2 System Description

Raw water for plant use will be obtained by pumping from a well system that will withdraw groundwater from the alluvium near the White River.

The pumping station will consist of a fully enclosed surface structure housing pumps, motors, and electrical and mechanical systems, including full remote control from the process plant.

The pumping station will have the capacity to pump the average water requirement of 200 gpm (0.45 cfs), with allowance for peak plant demands. Delivery will be through a 6-inch-diameter pipe to a 20,000-barrel-capacity steel storage tank. The storage tank will provide operational flexibility and reserve storage for fire protection. This tank will be used for oil storage during commercial production phase operations.

Water will be pumped through a 6-inch-diameter pipeline from the storage tank to the process area. All pipelines will be buried below the frost depth for freeze protection and will be protected against corrosion, as required.

Electric power for the pumping station will be obtained from the process plant's 69-kilovolt distribution.

Water required during the construction of the process plant will be obtained from the well system near the White River.

3.14.3 PHASES III AND IV – COMMERCIAL OPERATION

Changes in both surface water and groundwater resources will be produced in Phases III and IV on Tracts U-a and U-b. The expected eventual changes are discussed in Section 5.2.

3.14.3.1 Facilities

The water supply facilities for Phases III and IV of the White River Shale Project, which are shown in Figure 3.4-2, consist of:

- A pumping station located on the south bank of the reservoir on the White River

- A 2.0-mile pipeline from the pumping station to an on-tract storage pond
- An on-tract storage pond at the terminal end of the pipeline
- A 0.4-mile pipeline to the plant area

The Phase III and IV water requirements were estimated to range from 13,000 to about 26,000 acre-feet per year, as shown in Table 3.14-2. A further discussion is found in Section 7.14.

Table 3.14-2

PHASES III AND IV WATER REQUIREMENTS

Line	Water Requirement	
	Average (gpm)	Annual Average (acre-feet)
Practical minimum requirement:		
Process plant	5,960	9,700
Processed shale dust control and irrigation, and other undefined uses	1,000	1,600
Other losses, including seepage and evaporation	1,040	1,700
Total minimum requirement	8,000	13,000
Practical maximum requirement:		
Minimum requirement		13,000
Add: raw water for 100% water cooling the process and utility plants		8,750
Add: contingency, 20%		4,250
Total maximum requirement		26,000

3.14.3.2 System Description

Raw water for plant and processed shale uses will be pumped from the White River Reservoir through a 24-inch-diameter pipeline.

The 6-inch-diameter pipeline installed for Phase II operation will be incorporated into the Phase III and IV system for backup. The pumping station at the reservoir will be a fully enclosed structure housing screened intakes, pumps, motors, electrical switchgear, and mechanical systems. The pumps will be capable of pumping the average water requirement, with allowance in capacity for peak demands. Supervisory and telemetering equipment will be included to provide full remote control from the process plant control room. Electric power supply for the pumping station will be provided via pole line from the White River Shale Project power distribution system.

The on-tract freshwater storage pond will be constructed to provide operational flexibility, including 3 days' reserve and additional storage to maintain a reliable supply of water during an outage of the reservoir pumping station or pipeline and to control drainage water. Although no subsurface exploration or material testing have been performed, the pond will be formed by an earthfill dam constructed by making maximum use of local materials.

Water will be distributed from the pond to the plant and to the processed shale disposal area by an outlet system that will permit the flow to be synchronized for delivery to either the plant or the processed shale area or both. The average plant demand and the processed shale control requirement will be delivered by gravity from the storage pond through separate 16-inch-diameter pipelines.

All pipelines will be buried below the frost depth for freeze protection and will be protected against corrosion, as required.

Water required during construction of the facilities will be obtained from the water system constructed for Phase II.

3.14.4 WATER TREATMENT

During Phase II, raw water (well water) stored in a tank will be pumped to the water treatment plant consisting of a media filter and chlorinator. Water used for boiler feedwater makeup will be deaerated and demineralized by ion exchange.

During Phases III and IV, raw water (White River water) stored in the reservoir will be delivered by gravity to the water treatment plant, which will consist of a flash mixer, a flocculation tank, a sedimentation tank, and a media filter.

Treated water (50 gpm during two-train operation) used for drinking, in sanitary facilities, and in the cafeteria will be chlorinated. Water used for boiler feedwater makeup will be deaerated and demineralized by ion exchange.

Potable water, process water, and boiler makeup water will be stored in three separate storage tanks, each with 12 hours' minimum supply capacity. Each treatment system will be designed to provide a guaranteed supply of treated water. The water treatment plant will be located at the southwest corner of the process area.

Section 3.15

Section 3.15

WASTEWATER MANAGEMENT PLAN

The wastewater management plan for the White River Shale Project is aimed at water conservation through maximum resue of treated wastewater and through minimum consumption of fresh water.

3.15.1 SEQUENCE OF DEVELOPMENT

The wastewater management plan involves the development of different collection and treatment facilities in a three-step sequence. This sequence is keyed to requirements during construction and operation of three phases of WRSP process facilities: Phase II, single retort operation; Phase III, first-train commercial operation; and Phase IV, full commercial operation. The sequence of development and the duration of use of the different wastewater collection and treatment facilities are shown in Figure 3.15-1. Each of these facilities will be replaced by

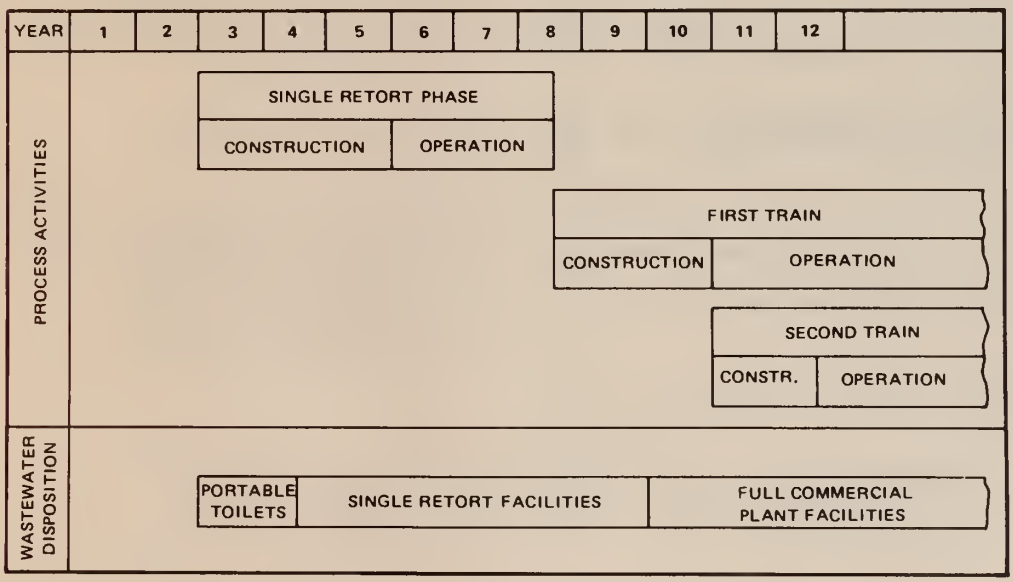

Figure 3.15-1. Waste Management Plan

the following one in accordance with the projected requirements for the three phases.

During the early part of construction of Phase II, portable toilets will be used for sanitary waste disposal. Other kinds of wastewater control will be provided, as discussed in Subsection 3.13.5.2.

A wastewater collection and treatment facility will be developed for use during the latter part of Phase II construction, during the Phase II operating phase, and during the early part of Phase III construction.

A separate system of wastewater collection and treatment will be provided to handle expected wastewater flows during Phase III operation and during the construction and operation of Phase IV.

Water use and wastewater flow rates are shown in Figure 3.15-2 for the single retort stage and in Figure 3.15-3 for commercial plant operation. The scheme for collection, treatment, and reuse will be basically the same during the three phases of the WRSP. However, the wastewater flow rates will be different because of the substantial variation in the process units employed in each stage. A summary of the wastewater sources, methods of collection, and treatment and reuse schemes follows.

3.15.2 WASTEWATER SOURCES AND CHARACTERISTICS

Maximum reuse of treated wastewater and minimum consumption of fresh water will require that the wastewater streams be segregated and treated according to the type and level of contaminants they contain.

The major wastewater streams are:

- Oily wastewater, mainly from washdown of the process and utility plant areas. Major contaminants include oil, suspended solids, and dissolved organics.

WATER AND WASTEWATER CHARACTERIZATION (ESTIMATED)								
COMPONENT \ STREAM		(1) RAW WATER	(2) SERVICE WATER	(4) SOUR WATER STRIPPER BOTTOMS	(5) OILY WASTE-WATER	(6) SANITARY WASTE-WATER	(7) TREATED LOW-TDS WASTE-WATER	(8) HIGH-TDS WASTE-WATER
FLOW	GPM	100	85	25	18	9	42	10
pH	UNITS	7-8.5	7-8.5	8.5-9.5		7.0-8.5	6.5-7.5	
DISSOLVED SOLIDS	mg/l	400-800	400-800		600-2,000	800-1,000	1,000-2,000	5,000-10,000
SUSPENDED SOLIDS	mg/l	300-1,000	20-50		30-500	200-300	~30	100-500
CHEMICAL OXYGEN DEMAND	mg/l			500-1500	100-2,000 (a)		~50	
BIOCHEMICAL OXYGEN DEMAND	mg/l				50-500 (a)	150-250	~20	
OIL AND GREASE (TOTAL)	mg/l	0-5	NIL	50-100	50-1,000	20-50	<5	
PHENOLS	mg/l	<1		80-150		<1	<1	
AMMONIA	mg/lN	<1		25-50		10-15		
TOTAL PHOSPHATE	mg/l PO_4	0-1				5-10		
TOTAL HARDNESS	mg/l $CaCO_3$	200-350						
TOTAL ALKALINITY	mg/l $CaCO_3$	150-250						

(a) FILTERED SAMPLE

NOTES:

(A) ALL FLOWS ARE IN GALLONS PER MINUTE, AND, EXCEPT FOR STORM RUNOFF, REPRESENT AVERAGE DRY WEATHER CONDITIONS.
(B) NO ALLOWANCE IS MADE FOR FIRE PROTECTION.
(C) WATER USE AND CHARACTERIZATION DATA ARE APPROXIMATE ESTIMATES AND WILL BE REVISED AS NEW INFORMATION IS DEVELOPED.
(D) SANITARY WASTEWATER FROM EMPLOYEE FACILITIES INCLUDES SANITARY WASTEWATER FLOW FROM THE MINE.
(E) PROCESS STEPS SHOWN DASHED MAY BE REQUIRED IF REUSE APPLICATIONS CHANGE.
(F) WATER BALANCE SUMMARY

MAIN SOURCE	FLOW		DISPOSITION
FRESHWATER SUPPLY	180	85	IN PROCESSED SHALE
		4	IN SLUDGES (INCLUDES SULFUR SLURRY)
		16	MISCELLANEOUS LOSSES
		15	COOLING TOWER LOSSES (EVAPORATION AND DRIFT)
		60	DUST CONTROL LOSSES (MINE AND DISPOSAL SITE)
TOTAL IN	180	180	TOTAL OUT

(G) WATER DEMANDS AND WASTEWATER PRODUCTION RATES DURING CONSTRUCTION PHASES ARE SUMMARIZED IN SUBSECTIONS 3.19.6.3 AND 3.19.6.4
(H) THE IMPOUNDED STORM RUNOFF AND LEACHATE FROM THE PROCESSED SHALE AREA WILL BE REUSED FOR COMPACTION AND DUST CONTROL OF NEWLY PLACED PROCESSED SHALE. THE AMOUNT OF IMPOUNDED STORM RUNOFF WILL DIMINISH AS THE CANYON IS GRADUALLY FILLED WITH SHALE. ANY LEACHATE AND MINIMAL RUNOFF THAT MAY ACCUMULATE BEHIND THE CATCHMENT DAM AFTER DECOMMISSIONING WILL EVAPORATE.

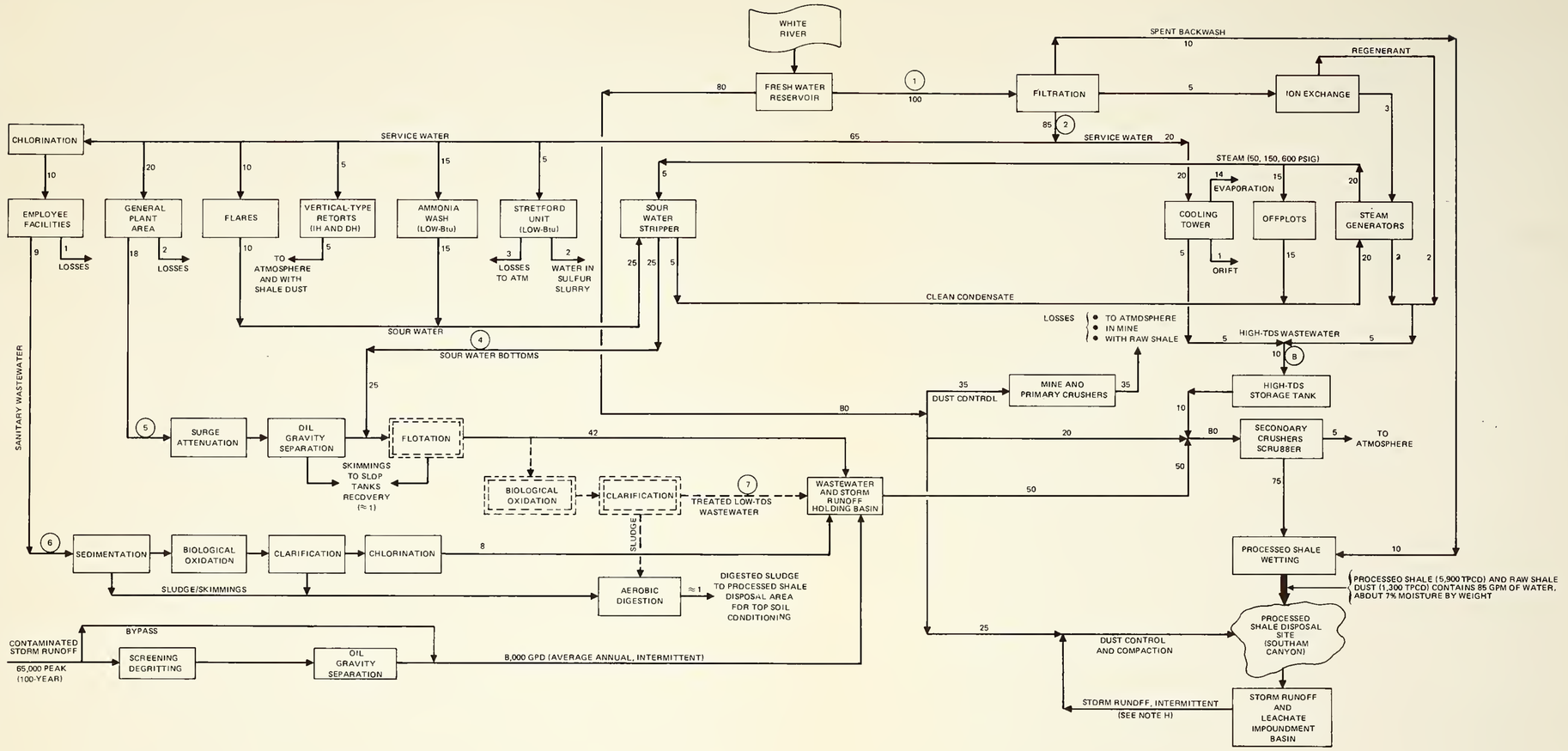

Figure 3.15-2. Water Balance, Phase II

WATER AND WASTEWATER CHARACTERIZATION (ESTIMATED)

COMPONENT \ STREAM		① RAW WATER	② SERVICE WATER	③ BOILER FEED	④ SOUR WATER STRIPPER BOTTOMS	⑤ OILY WASTE-WATER	⑥ SANITARY WASTE-WATER	⑦ TREATED LOW-TDS WASTE WATER	⑧ HIGH-TDS WASTE-WATER
FLOW	GPM	4,590	3,710	1,850	450	290	45	735	755
pH	UNITS	7.8-8	7.8-8	9.9-10	8.5-9.5	7.9	7.0-8.5	6.5-7.5	
DISSOLVED SOLIDS	mg/l	400-800	400-800	50-100		500-2,000	800-1,000	1,000-2,000	5,000-10,000
SUSPENDED SOLIDS	mg/l	300-1,000	20-50	NIL		30-500	200-300	30	100-500
CHEMICAL OXYGEN DEMAND	mg/l			NIL	500-1500	100-2,000[a]		50	
BIOCHEMICAL OXYGEN DEMAND	mg/l					50-500[a]	150-250	20	
OIL AND GREASE (TOTAL)	mg/l	0-5	NIL	NIL	50-100	50-1,000	20-50	<5	
PHENOLS	mg/l	<1		NIL	80-150		<1	<1	
AMMONIA	mg/lN	<1		NIL	25-50		10-15		
TOTAL PHOSPHATE	mg/l PO_4	0-1		NIL			5-10		
TOTAL HARDNESS	mg/l $CaCO_3$	200-350		<5					
TOTAL ALKALINITY	mg/l $CaCO_3$	150-250		<5					

(a) FILTERED SAMPLE

NOTES:

(A) ALL FLOWS ARE IN GALLONS PER MINUTE AND, EXCEPT FOR STORM RUNOFF, REPRESENT AVERAGE DRY WEATHER CONDITIONS.
(B) NO ALLOWANCE IS MADE FOR FIRE PROTECTION.
(C) WATER USE AND CHARACTERIZATION DATA ARE APPROXIMATE ESTIMATES AND WILL BE REVISED AS NEW INFORMATION IS DEVELOPED.
(D) SANITARY WASTEWATER FROM EMPLOYEE FACILITIES INCLUDES SANITARY WASTEWATER FLOW FROM THE MINE.
(E) PROCESS STEPS SHOWN DASHED MAY BE REQUIRED IF REUSE APPLICATIONS CHANGE.
(F) DURING FIRST TRAIN STAGE OPERATION (50,000 BPCO) WATER DEMANDS AND WASTEWATER PRODUCTION RATES ARE EXPECTED TO BE 50% OF THOSE VALUES SHOWN HERE FOR THE TWO TRAIN STAGE OPERATION (100,000 BPCO).
(G) WATER BALANCE SUMMARY

MAIN SOURCE	FLOW		DISPOSITION
FRESH WATER SUPPLY	5,940	2,170	IN PROCESSED SHALE
		25	IN SLUDGES (INCLUDES SULFUR SLURRY)
SYNTHESIS/PRODUCT FEED	125	870	MISCELLANEOUS LOSSES (INCLUDES HYDROGEN PLANT CHEMICAL CONSUMPTION)
		1,820	COOLING TOWER LOSSES (EVAPORATION AND DRIFT)
		1,180	DUST CONTROL LOSSES (MINE AND DISPOSAL SITE)
TOTAL IN	6,065	6,065	TOTAL OUT

(H) WATER DEMANDS AND WASTEWATER PRODUCTION RATES DURING CONSTRUCTION PHASES AND SUMMARIZED IN SUBSECTIONS 3.19.6.3 AND 3.19.6.4.
(I) THE IMPOUNDED STORM RUNOFF AND LEACHATE FROM THE PROCESSED SHALE AREA WILL BE REUSED FOR COMPACTION AND DUST CONTROL OF NEWLY PLACED PROCESSED SHALE. THE AMOUNT OF IMPOUNDED STORM RUNOFF WILL DIMINISH AS THE CANYON IS GRADUALLY FILLED WITH SHALE, ANY LEACHATE AND MINIMAL RUNOFF THAT MAY ACCUMULATE BEHIND THE CATCHMENT DAM AFTER DECOMMISSIONING WILL EVAPORATE.
(J) WATER QUANTITIES SHOWN ARE MINIMUM QUANTITIES RESULTING FROM INITIAL FEASIBILITY STUDY. REFER TO TABLE 3.14-2 AND TO SECTION 7.14.

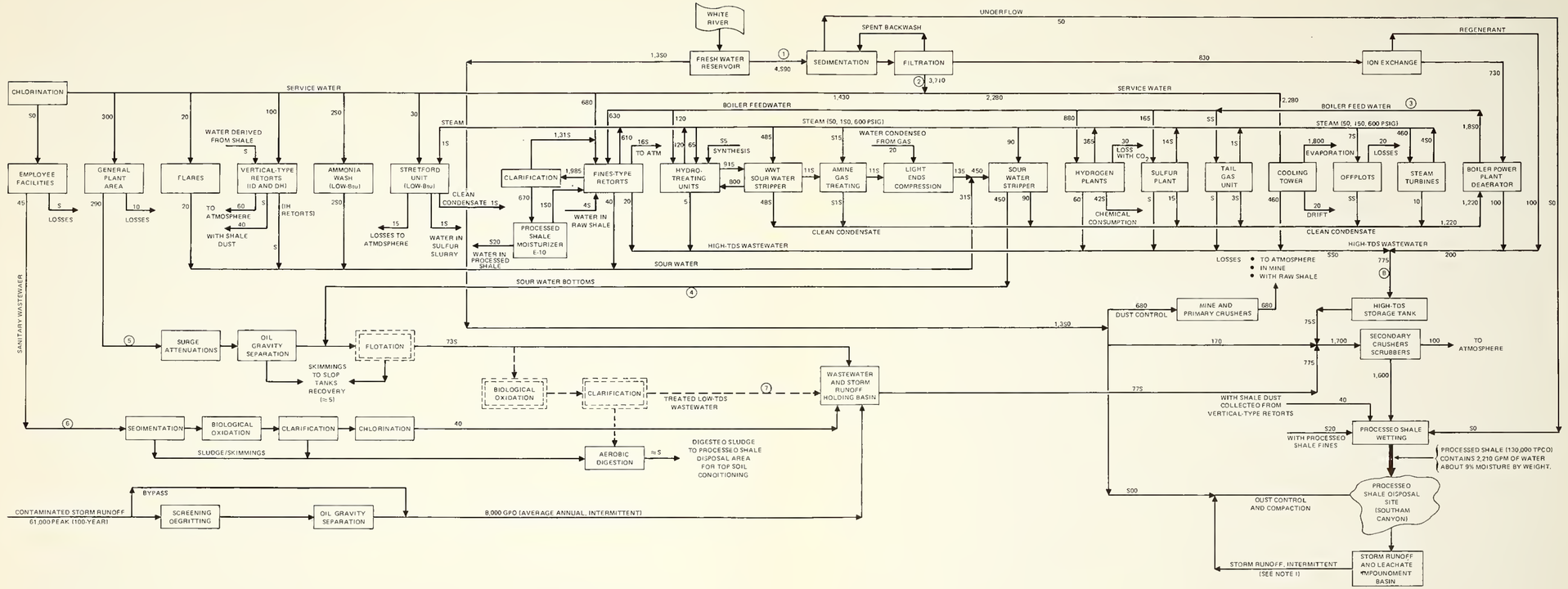

Figure 3.15-3. Water Balance, Phase III and Phase IV

- Sour water, from the retorting and upgrading process facilities. Major contaminants include ammonia, sulfide, phenols, and other organics.
- Sanitary wastewater, from employee facilities. Major contaminants include suspended solids, organics, and nutrients. Portable toilets are used in the mine. The chemicals used in these toilets are biodegradable.
- Blowdown, from the steam system and cooling tower in the utility plant and various process units. Major contaminants include dissolved inorganics.
- Storm runoff, from contaminated and potentially contaminated areas. Major contaminants include suspended solids and, occasionally, oil.
- Mine water. Water from the mine is expected to be saline, but its production rate is expected to be low. If the production rate is sufficient, the water will be used for dust control inside the mine, thus reducing the overall freshwater demand. Any remaining water will be used in other project activities, such as surface dust suppression.

An inventory of the wastewater streams expected during Phase II and Phases III and IV is shown in Table 3.15-1. The flows during first-train operation are expected to be about 50 percent of these estimated for full commercial plant operation.

3.15.3 WASTEWATER COLLECTION

The wastewater streams will be segregated and collected in separate sewers and/or pipes according to the type and level of contamination. There will be four separate sewer systems:

- Oily. The oily sewer network will receive the stripped sour water and plant washdowns.
- High TDS. Blowdown from the utility plant and from various process units will be collected through the high-TDS sewer network and discharged into the high-TDS storage tank. Excess mine water (saline water), if present, will also be collected and discharged into the high-TDS storage tank.

- Sanitary. Wastewater from all aboveground employee facilities will be collected through a sanitary sewer network and discharged into a primary sedimentation tank. Sanitary wastewater generated in the mine will be collected in portable toilets; the liquid in these toilets will be recycled and solids stored in a tank attached to the toilets. When the storage tank is full, its contents will be transferred to the sanitary sewer through which they will reach the aboveground treatment system.
- Stormwater. Runoff from contaminated and potentially contaminated areas (including the process area, tank farm, shale stockpiles, and product pipeline pump station) will be collected through a network of gutters, culverts, and sewers and discharged into the stormwater screening and degritting basin (see Subsection 3.13.3). If there is runoff from the processed shale disposal site in Southam Canyon, it will be captured in an impoundment at the north end of the canyon (see Subsection 3.10.5).

The sanitary, oily, and stormwater sewer flows will be combined, after treatment, to form the low-TDS wastewater stream.

3.15.4 WASTEWATER TREATMENT SYSTEM

The wastewater treatment concept is based on eliminating wastewater discharge to the White River and minimizing the project's freshwater consumption through complete use and reuse of the treated wastewater. The minimum water requirement of 13,000 acre-feet per year was used in developing the water balance shown in Figure 3.15-3.

As shown in Figures 3.15-2 and 3.15-3, the wastewater streams will be segregated on the basis of type and level of contamination.

Process wastewater streams that contain high TDS concentrations will be collected and routed to the storage tank without treatment. These streams are expected to contain primarily inorganic salts and small amounts of organics and nutrients.

Table 3.15-1

WASTEWATER STREAMS SUMMARY[a]

Wastewater Stream	Source		Flow, gpm: Phase II	Flow, gpm: Phases III and IV	Major Contaminants	Collection	Remarks
Sour water	Process Plant	Vertical-type IH retorts		5	Organics Ammonia Phenol Sulfide	Oily sewer (after stripping)	During commercial plant operation, 800 gpm of the stripped sour water is reused in the hydrotreating units. Net discharge to the sewer is 450 gpm.
		Fines-type retorts		40			
		Low-Btu gas treating	15	250			
		Hydrotreating units		915			
		Light ends compression		20			
		Gas flares	10	20			
			25	1,250			
Blowdown	Process Plant	Fines-type retorts		20	Inorganic salts	High-TDS sewer	
		Hydrotreating units		5			
		Hydrogen plant		60			
		Sulfur plant		5			
		Tail gas units		5			
				95			
Blowdown	Utility Plant	Cooling tower	5	460	Inorganic salts	High-TDS sewer	Steam generators will be used during Phase II.
		Power and boiler plant }	5	100			
		BFW treatment }		100			
			10	660			
Washdown	General Plant Area	General process area	20	290	Suspended matter Organics	Oily sewer	
Sanitary wastewater		Employee facilities	10	45	Suspended matter Organics Nutrients	Sanitary sewer	
Contaminated storm runoff		General plant area, product pump station, and tank farms	40 acre-feet	45 acre-feet	Suspended matter Organics	Storm sewer, culverts, ditches	Volume for expected surface runoff during the 100-year storm.
Saline mine water	Mine	Groundwater	Nil	Nil	Inorganic salts	High-TDS sewer	If present, the stream will be used for dust control inside the mine. Any excess will be used for processed shale wetting.

(a) Flows during first-train operation are projected to be about 50 percent of those expected during full commercial plant operation.

Sanitary wastewater collected from employee facilities will be routed to a sedimentation basin and then to biological oxidation treatment units. The biologically treated effluent will be disinfected and discharged to the wastewater and storm runoff holding basin.

Plant washdown streams will be discharged into a surge-equalization basin and then deoiled before being routed to the flotation unit; the sour water stripper bottoms stream will be routed directly to the flotation unit. The flotation unit effluent will then be discharged to the low-TDS wastewater storage pond.

Plant area runoff expected from the 100-year frequency storm will be impounded in the holding basin. The impounded water will be screened, degritted, and then deoiled, if necessary.

The foregoing wastewater treatment concept is based on the assumption that little mine water will be produced. However, if mine water production is substantial, the excess mine water will be used for wetting the processed shale. The effluent from the holding basin will be treated further by a biological oxidation process to reduce its organic content and may be used as cooling tower makeup.

Skimmed oil and oily sludges collected in sumps, oil separators, manholes, etc., will be held in a slop tank and processed for recovery. The stabilized biological sludge will be temporarily stored until it can be used at the processed shale disposal site for soil conditioning.

3.15.5 WASTEWATER REUSE

Reuse of the following wastewater streams during commercial plant operation is planned:

- Sour Water. The sour water from the hydrotreating units will be stripped in the wastewater treatment sour water stripper and then reused again in the hydrotreating

units (800 gpm). The wastewater treatment stripper net bottoms (115 gpm) will be reused in the amine gas treating and in the light ends compression units. The remaining sour water streams will then be stripped in a separate sour water stripper before transport to the wastewater treatment facilities at a rate of 450 gpm.

- Clean Condensate. All clean condensates generated in the process and utility plants will be segregated and reused as boiler feedwater. This stream is expected to amount to 1,220 gpm.
- Fines-Type Scrubber Water. The fines-type scrubber water will be clarified and recycled to the scrubbers. The underflow from the clarifier will be used to quench and wet the processed shale; 520 gpm will be retained on the processed shale. The makeup to the scrubbers' demand of 1,995 gpm will be 680 gpm, accounting for the water left on the processed shale and evaporation losses to the atmosphere.
- Combined Wastewater. After appropriate treatment, the sanitary and oily wastewater streams will be reused as makeup to the scrubbers for the secondary crushers (1,700 gpm).
- Processed Shale Moisturizer Water. The effluent from the secondary crusher scrubbers (1,600 gpm) will be reused as makeup to the processed shale moisturizer. The steam from the moisturizer will be condensed and reused in the moisturizer.
- Stormwater. The stormwater collected in the process area will be treated and then reused, along with other wastewater, as makeup to the scrubbers for the secondary crushers. The runoff collected at the processed shale disposal site will be used for dust control and compaction purposes at the site.

Section 3.16

Section 3.16

CORRIDOR PLANNING

3.16.1 CORRIDOR DEVELOPMENT PROGRAM

The Bureau of Land Management (BLM) has developed a program for BLM-administered land of routing transportation and utility services in a few selected patterns. Using existing routes as a guide, the BLM has evaluated known developable resources as well as existing land uses and has selected routings, known as corridors, to be used on a preferred basis by future installations. These corridors will be for multiple use wherever possible so that roads, pipelines, etc., that follow roughly parallel routes can be grouped together. The purpose of selecting corridors is to minimize environmental impact on the area while still providing all necessary services.

3.16.2 ACCESS ROADS

The Vernal area will probably furnish the major location for permanent housing for workers employed on the project. Therefore, access from Vernal has been considered the primary corridor to the project. The corridor from Vernal is southeast along U.S. 40 to Route 45, south along Route 45 through Bonanza and across the White River to a point about three-quarters of a mile inside the northern boundary of Tract U-b, and then southwest along a new road to the plant site (see Figure 3.16-1).

The corridor for the access road will be the same in Phase II, single retort operation, and Phases III and IV, commercial plant operation; however, major improvements and new construction will take place in

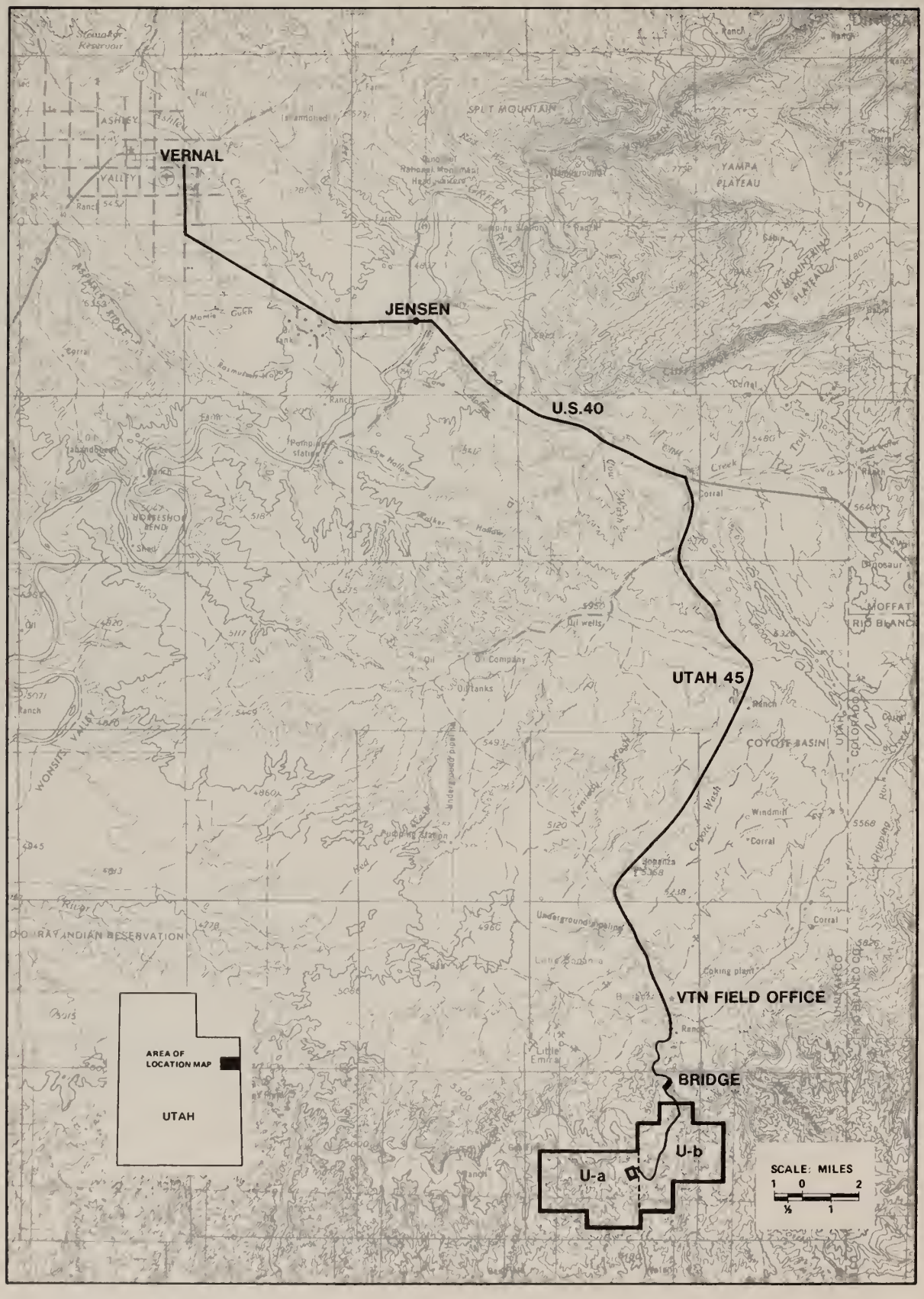

Figure 3.16-1. Corridors to WRSP Site

the section between Bonanza and the plant site (see Figure 3.16-1). Maintenance and minor improvements will be made along the remainder of the access road.

For Phases III and IV, major improvements will be made to Route 45 between U.S. 40 and Bonanza. No major improvements are planned on U.S. 40.

3.16.3 POWER LINES

The existing corridor from the substation at Vernal to the substation at Bonanza will be used to expand the service to 69 kilovolts. From Bonanza to the plant site, the new 69-kilovolt line will share the access road corridor.

The 69-kilovolt line will be built during the Phase II construction period and will be completed before Phase II startup.

Electrical power to miscellaneous offsite places, such as the processed shale disposal area and water supply pumping station, will be distributed from the substations in each phase. The distribution line to the water pumping plant will follow the water supply line route. Power to the processed shale disposal area will follow the conveyor and its maintenance road route.

3.16.4 WATER SUPPLY LINES

The water supply system will be completely on tract; there will be no off-tract corridors. The raw water supply line will run from the pumping plant to the plant site area, as shown in Figures 3.4-1 and 3.4-2.

3.16.4.1 Phase II – Single Retort Operation

In Phase II, the raw water supply line will terminate at the raw water tank. From there, water will be distributed throughout the plant area. There will be no water lines to the processed shale disposal area in this phase. Any additional water required for uses such as dust control, drinking water, etc., will be hauled in tanks and trucks.

3.16.4.2 Phases III and IV – Commercial Operation

In Phases III and IV, the raw water supply line will run from the pumping plant to the water reservoir south of the plant site. All river water used in the project will be distributed from the reservoir. A pipeline will be run from the reservoir to the processed shale disposal area (see Figure 3.4-2). In the processed shale disposal area, much of the line will be irrigation-type piping that can be moved with the operation as required.

3.16.5 PRODUCT PIPELINE

During Phase II, the relatively small amount of crude shale oil produced will probably be transported in tanker trucks. However, it is possible that the product could be transported through an existing pipeline to a Colorado refinery or railhead.

In Phases III and IV, the product will be upgraded shale oil, which will be transported in a new pipeline to Casper, Wyoming, and on to a common carrier.

Off tract, the new pipeline will use existing BLM corridors across federal lands through the Rangely, Colorado, area and then to Colorado State Highway 64. From Highway 64 to Sunbeam, Colorado, the pipeline will follow an existing Amoco right-of-way. From Sunbeam, the line will proceed along a new corridor to Wamsutter, Wyoming, and from Wamsutter it will follow Amoco and Pasco rights-of-way to Casper, Wyoming.

Section 3.17

Section 3.17

PRODUCT TRANSPORT

During the single retort operation, the most probable means of transporting shale oil will be by tanker trucks. During commercial operation, it will be transported by pipeline.

The pipeline that will transport shale oil from the White River Shale Project facility in northeastern Utah to common carrier pipelines at Casper, Wyoming, will consist of 280 miles of buried 16-inch o.d. pipe. Equipped with three electrically driven pump stations totaling 11,400 hp, the pipeline will be capable of delivering 96,000 BPD of refined shale oil to Casper. A map of the proposed pipeline route is shown in Figure 3.17-1.

The product transport plans cover the following items:

- Power cost
- Right-of-way
- Property acquisition
- All communications and control equipment chosen for operation by minimum manpower

3.17.1 PUMPING STATIONS

The initial pump station will be located on a 1-acre site at the shale oil process plant northwest of the tankage area and at a lower elevation than the tanks to permit positive suction to the pump manifold. This station will operate with three 1,200-bhp, electric-motor-driven centrifugal pumps, and a fourth unit will be on standby. The two booster pump

stations, located at 80-mile intervals down the pipeline, will each operate with three electric-motor-driven centrifugal pumps, with a fourth unit as standby. Station 2 will have 1,600-hp units and will be near Sunbeam, Colorado, on State Highway 318. Station 3 will have 1,000-hp units and will be near Wamsutter, Wyoming, on Interstate 80. Moon Lake Electric Association, Inc., will supply power at all the stations.

The White River pump station site will be at an elevation of 5,300 feet from which the pipeline will drop to an elevation of less than 5,000 feet for the White River crossing, which is the low point on the pipeline. To minimize pipeline construction cost, this crossing should be installed before the reservoir dam is completed.

3.17.2 PIPELINE ROUTE

The pipeline route, as shown in Figure 3.17-1, will run in a general northeast direction, passing close to Rangely, Colorado, and crossing Interstate Highway 80 approximately 40 miles west of Rawlins, Wyoming. The pipeline will cross the Yampa, Little Snake, and Sweetwater Rivers and will have about 20 highway and road crossings. Because the route crosses a plateau containing the Great Divide Basin (which also forms the Continental Divide), most of the pipeline will be at about 6,800-foot elevation. The route passes to the west of the Seminoe and Pathfinder Reservoirs as it descends to Casper, which has an elevation of 5,300 feet. The terminus of the pipeline will be the common carrier pipeline tank farms in Casper.

The pipeline route joins the waterline right-of-way (ROW) 0.7 mile northeast of the product pump station and shares the waterline ROW to the water pump station for a distance of 0.9 mile. The product pipeline will normally require a ROW 50 feet wide and a ditch 4 feet deep, providing approximately 30 inches of cover. Where the water and product lines share the same ROW, a 65-foot ROW should be provided.

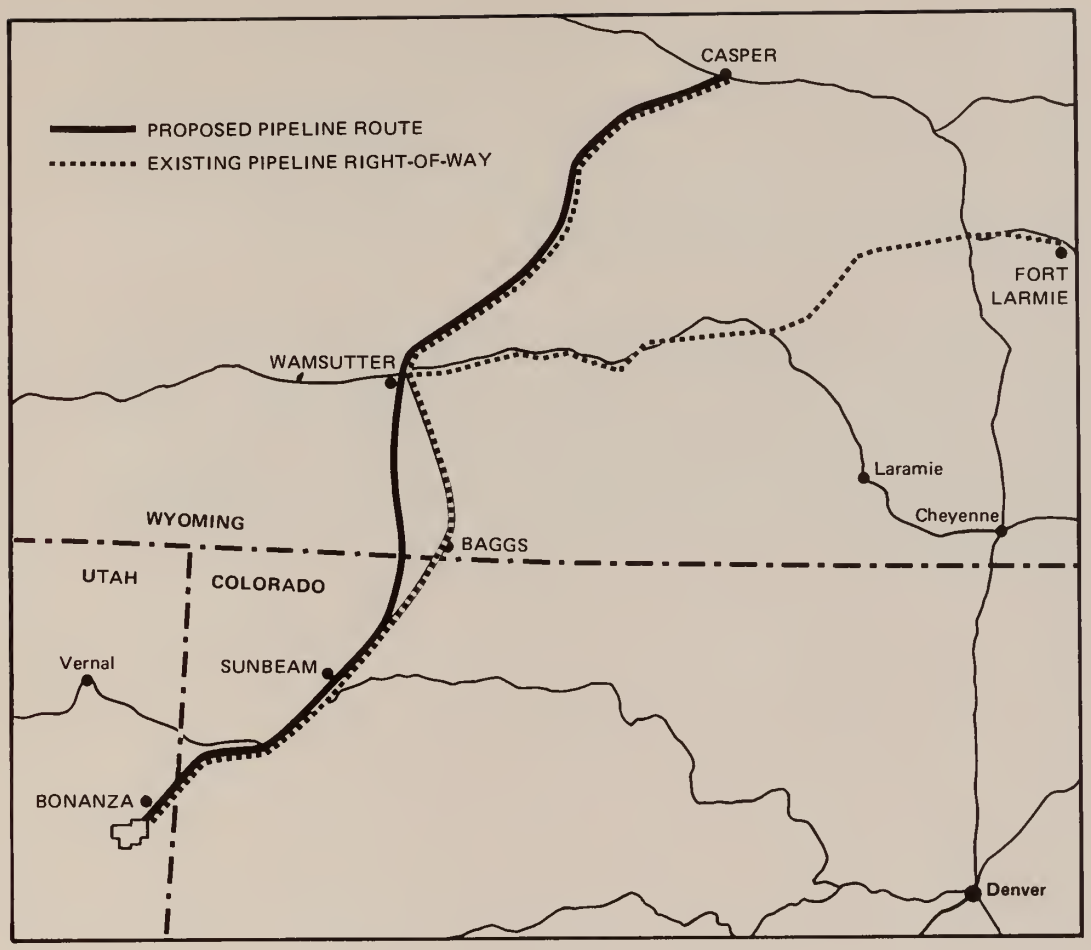

Figure 3.17-1. Pipeline Route

The product pipeline will share an ROW with the water pump station access road to the highway, a distance of 1.4 miles. From this point, it is only 0.6 mile to the White River crossing, on the north side of which the product line joins the existing ROW of the Gilsonite pipeline for a distance of 3.2 miles.

Near Bonanza, Utah, the product line switches from the Gilsonite pipeline route and parallels the road from Bonanza to Colorado State Highway 64, a distance of 13.5 miles. From there it follows the Amoco pipeline ROW to the town of Sunbeam, Colorado, a distance of 57 miles.

From Sunbeam to Wamsutter, the product pipeline takes a direct, northerly route, saving at least 10 miles over the existing Amoco ROW that follows a less direct route to Wamsutter. From Wamsutter to Casper, the product line once again follows existing pipeline ROWs owned by either the Amoco or the Pasco pipeline.

The pipeline will contain block valves, with an average spacing of 25 miles. Scraper traps will be located at each pump station. Coaxial cable will be used for communications and supervisory control of all stations and mainline valves, which are normally unattended and remotely operated.

Section 3.18

Section 3.18

BY-PRODUCT PLAN

In the most probable plan of operation, White River Shale Project will generate a limited number of by-products that will be disposed of during Phases III and IV. These are:

- Ammonia – about 410 tons per day
- Sulfur – about 165 tons per day

According to the plan, the by-products will leave the site by truck, probably to serve the fertilizer or chemical industries.

During Phase II, there are no by-products to be shipped from the site. Small quantities of crude sulfur will be disposed of with the processed shale.

Section 3.19

Section 3.19

CONSTRUCTION PLAN

This section describes the plan for construction of oil shale mining and processing facilities at Tracts U-a and U-b. This plan included all field operations necessary for establishing access and moving workers, equipment, and materials into the area; for housing and providing for workers and their families at the Bonanza campsite; and for the major construction activity at the mining site. Construction at the mining site will include excavation and preparation of the site for plant construction and for the installation of all buildings, equipment, and support structures necessary to implement the Phase II, Phase III, and Phase IV plants. All construction materials and equipment will be shipped by rail to Craig, Colorado (the nearest railhead), and trucked to the plant site. For modifications in this plan necessary for implementing alternatives, see Part 7 of this Detailed Development Plan.

3.19.1 CONSTRUCTION PHASES

As shown in Figure 3.19-1, the mining development program will proceed in four major phases. Each of these phases — initial mine access, single retort operation, first-train operation, and two-train operation — will involve operations at the mining site. These operations have been carefully planned and phased to allow orderly development of the mining facility, to minimize construction costs and unnecessary excavations, and to avoid causing adverse environmental effects. The construction phases are defined in the following paragraphs.

3.19.1.1 Phase I — Initial Access Mine

In the initial mining operation, 6 months will be needed to sink two shafts approximately 1,100 feet deep, and then several months of mining operation will be needed to remove 30,000 tons of oil shale. Before this operation begins, a short access road will be built between the existing road and the mine.

3.19.1.2 Phase II — Single Retort Facility

During this phase, the single retorting facility will be built, and the initial mine will be further developed by enlarging one existing shaft and sinking one new shaft, both 26 to 28 feet in diameter. This work will require approximately 200 men and the transport of 10,000 tons of material and equipment to the site. Expanding the underground portion of the mine will necessitate removing 2,000,000 tons of oil shale, which will be stockpiled until the Phase II plant becomes operational.

Plant construction during this phase will require a peak work force of about 800 men and 40,000 tons of meterial and equipment at the site. To allow transport of men and material, the roads leading to the site must be improved before construction activities can begin. The estimated 5,000 BPCD of crude oil to be trucked from the site during the 2-year operation of the facility will also require improvements to the access roads. Although mining operations will continue, the single retort plant operation may be suspended before construction of the production plant is begun.

3.19.1.3 Phases III and IV — Commercial Plant

During this phase, the commercial production plant will be built, and the mine will be brought to full-scale production by sinking and equipping, on a phased basis, 12 additional shafts. This will require a work force of about 1,000 men and 50,000 tons of material and equipment at the site.

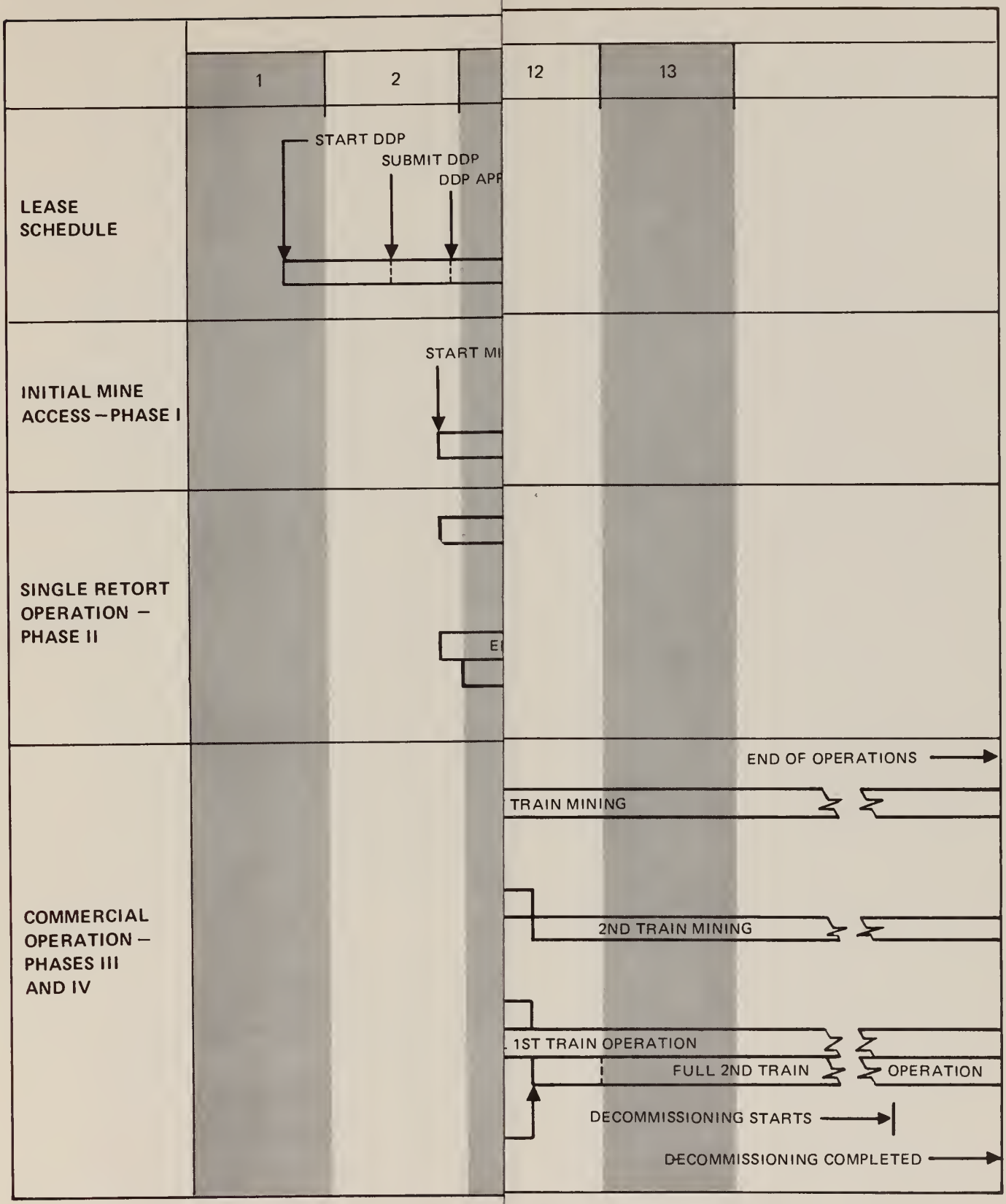

Figure 3.19-1. Mine Development Program – Four Phases

3.19.1.1 Phase I – Initial Access Mine

In the initial mining operation, 6 months will be needed to sink two shafts approximately 1,100 feet deep, and then several months of mining operation will be needed to remove 30,000 tons of oil shale. Before this operation begins, a short access road will be built between the existing road and the mine.

3.19.1.2 Phase II – Single Retort Facility

During this phase, the single retorting facility will be built, and the initial mine will be further developed by enlarging one existing shaft and sinking one new shaft, both 26 to 28 feet in diameter. This work will require approximately 200 men and the transport of 10,000 tons of material and equipment to the site. Expanding the underground portion of the mine will necessitate removing 2,000,000 tons of oil shale, which will be stockpiled until the Phase II plant becomes operational.

Plant construction during this phase will require a peak work force of about 800 men and 40,000 tons of meterial and equipment at the site. To allow transport of men and material, the roads leading to the site must be improved before construction activities can begin. The estimated 5,000 BPCD of crude oil to be trucked from the site during the 2-year operation of the facility will also require improvements to the access roads. Although mining operations will continue, the single retort plant operation may be suspended before construction of the production plant is begun.

3.19.1.3 Phases III and IV – Commercial Plant

During this phase, the commercial production plant will be built, and the mine will be brought to full-scale production by sinking and equipping, on a phased basis, 12 additional shafts. This will require a work force of about 1,000 men and 50,000 tons of material and equipment at the site.

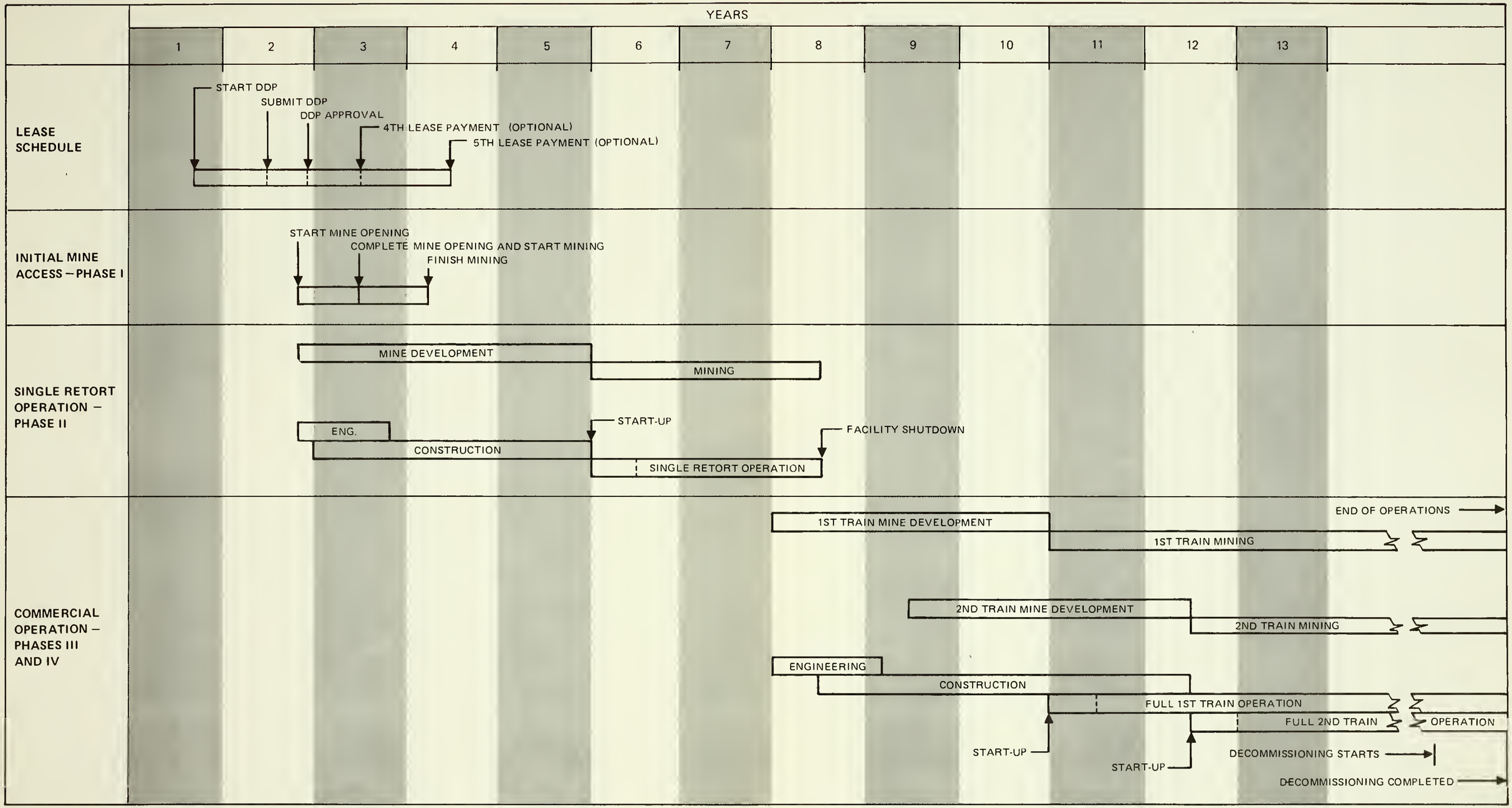

Figure 3.19-1. Mine Development Program – Four Phases

Oil shale removed for expansion of the underground portion of the mine will be stockpiled until the plant is operational. The mine will be developed in two phases to coincide with the completion of the first and second trains.

Building the two 50,000-BPCD process trains and their supporting facilities will be the main construction effort of the WRSP program. Consisting of two overlapping phases (Phase III for the first train and Phase IV for the second) of 2-1/2 years each and totaling 4 years, this effort will include major earth-moving operations, foundation laying, and equipment installation. It will require a peak work force of 3,935 manual and nonmanual workers and transport of 350,000 tons of material and equipment to the construction site.

3.19.2 CONSTRUCTION MANPOWER SCHEDULE

A schedule of manpower needed for mine development and plant construction is shown in Figure 3.19-2. Since mine development is a continuing activity, the mining manpower grows smoothly throughout Phases I through IV until it levels off at 1,050 men at full production. In contrast, the plant construction work force is temporary and peaks at about 800 men in Phase II and 3,900 men in Phases III and IV. The total manpower at the site will also include plant operation personnel, as discussed in Section 3.20.

3.19.3 CAMPSITE DEVELOPMENT

Construction workers will make a sizable transient addition to the local population. To help minimize adverse socioeconomic effects in the area, a temporary campsite will be established to provide housing, services, and recreation for site workers and their families, and for indirectly employed people who will come into the area to provide goods and services.

The campsite will be located at Bonanza, a distance of 5 miles north on Highway 45, across the White River from the construction site. It will consist of modular, transportable units (comparable to trailer homes), including both family and bachelor units as well as eating, shopping, and recreation facilities. It will be naturally landscaped to fit the terrain and will provide modern utilities to create a small, attractive city for the workers and their families.

3.19.3.1 Campsite Population

The campsite will be initially established during Phase II and expanded as the work force increases. Estimators from the WEA Study (Ref. 41) established requirements for the campsite. Using their estimates and the number of construction and operation workers shown in Figure 3.19-2 (which includes the plant operation work force discussed in Section 3.20), the projected campsite population is calculated to peak at about 7,000 people in the tenth year.

3.19.3.2 Campsite Utilities

The campsite will require telephone lines, electric power lines, a potable water supply, watewater treatment, and solid waste disposal. The estimated peak requirements for these utilities are shown in Table 3.19-1.

Table 3.19-1

CAMPSITE UTILITIES

	Phase II Construction	Phases III and IV Construction	Commercial Operation
Telephones	110	550	330
Electric power	3 MW	10 MW	3 MW
Potable water	100,000 gpd	400,000 to 700,000 gpd	100,000 gpd

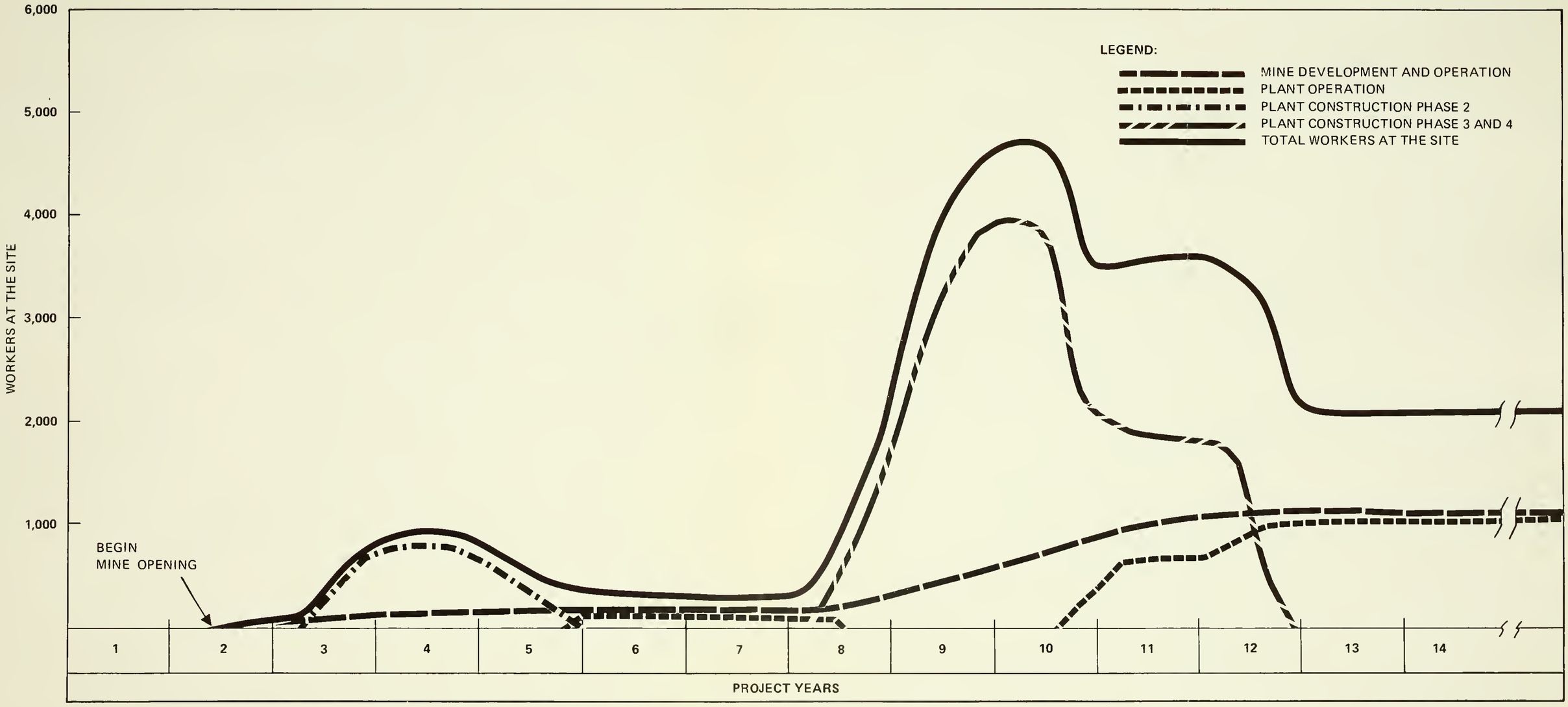

Figure 3.19-2. Manpower Schedule

3.19.3.3 Utility Development Schedule

Before Phase II begins, telephone lines, electric power lines, and potable water lines will be brought in from Bonanza. Wastewater will be treated by a packaged facility installed at the campsite, and solid waste will be disposed of by sanitary landfill. Of these utilities, only the peak electric power demand of 13 megawatts exceeds the local supply capacity, which is only 2 megawatts. When the demand for electric power exceeds the local substation capability of 2 megawatts, gas-turbine electric power generators will be installed at the construction site and lines will be installed to bring the power to the campsite.

3.19.4 SITE ACCESS

Construction materials and equipment will be shipped by rail to Craig, Colorado, and then trucked west on U.S. Highway 40 and south on State Highway 45 through Bonanza and across the White River to the site, a distance of 120 miles. With a total of 400,000 tons of material required, the average work-day traffic into the site for the 7 years of construction activity will be 25 tons per day of material. Peak rates could be much higher, and individual truck loads for transporting heavy machines, concrete mix, and other structural materials could reach 100 tons.

To handle this frequent and heavy traffic, Highway 45 will be upgraded between Bonanza and a point 2 miles south of the White River about 1 mile into the tract area. A new road will be cut and paved from this point to the building site. These road improvements will be made before Phase III begins. A new bridge capable of bearing 150-ton loads will be built across the White River before the start of Phase III.

3.19.5 SCHEDULE OF FIELD OPERATIONS

The field operations for constructing the WRSP facility have been planned for orderly implementation of the four construction phases. The major onsite construction tasks are site excavation, foundation work, and equipment installation. The schedule of these activities is shown in Figure 3.19-3 and discussed for each of the four construction phases in the remainder of this section.

3.19.5.1 Site Excavation

The main earth-moving operations will be required in the first 9 months of Phase II and in the first 12 months of Phase III. These will include leveling areas for buildings, parking, and plant construction; grading on-tract access roads; and excavating for the water supply reservoir, drainage control, and wastewater collection ponds. An estimated 200,000 cubic yards of earth will be moved in Phase II and another 800,000 cubic yards in Phase III when site excavation work is completed. Two methods will be used about equally: "blast and fill" and the more conventional "rip and haul." Rock crushers on site will reduce the size of rocks loosened by blasting to allow all of the material to be used for fill. Cut slopes will be 1:1 and fill slopes 2:1 (horizontal: vertical). A minimum of excess material will be dumped in the processed shale area.

3.19.5.2 Concrete Work

Concrete mix will be hauled to the site, mixed on site, and poured for building and machinery foundations. A total of 10,000 cubic yards of concrete required for Phase II will be poured at an average rate of 50 cubic yards per day in the summer months of Years 3 and 4.

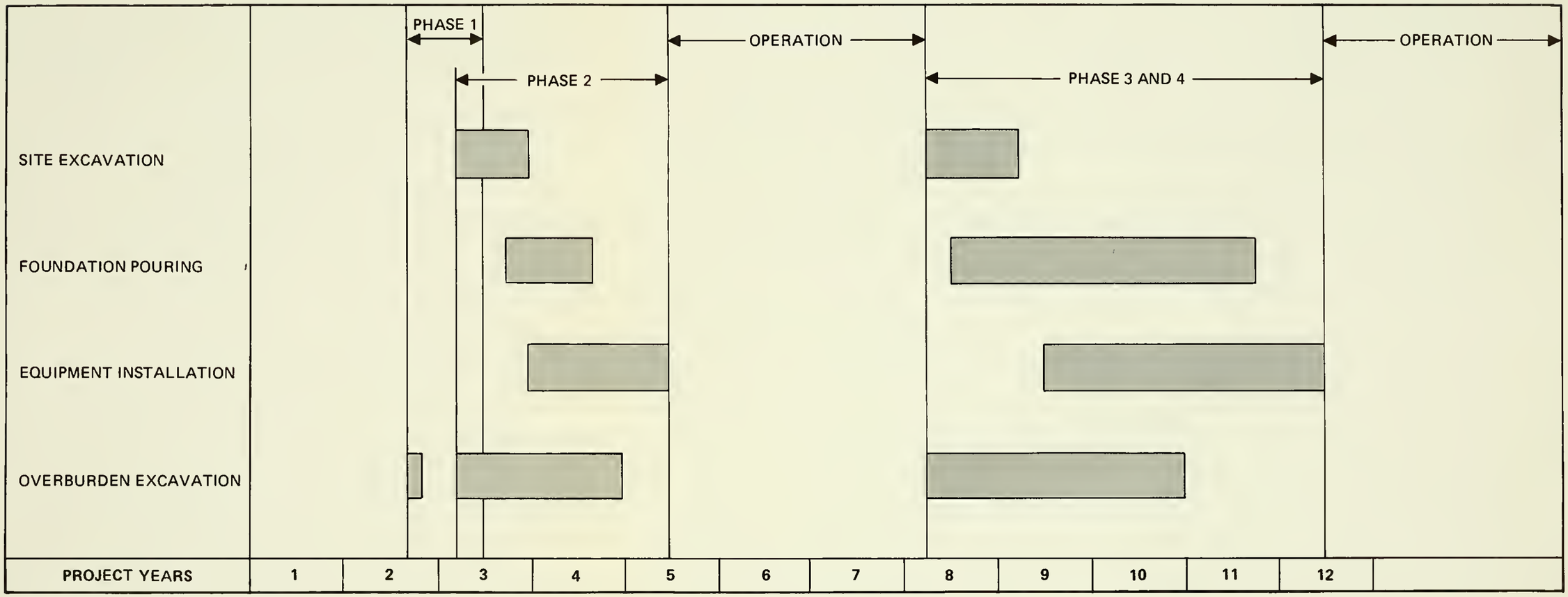

Figure 3.19-3. Schedule – Field Operations

For Phase III, a total of 30,000 cubic yards will be poured at an average rate of 100 cubic yards per day in the summer months of Years 9, 10, and 11. Peak output from the mixer could reach 500 cubic yards per day.

3.19.5.3 Equipment Installation

Installation of equipment includes all machine setting, piping, sheet-metal, electrical work, and erection of support structures. For Phase II, equipment installation will begin in the first quarter of Year 3 and end in the third quarter of Year 5 at the completion of the single retort plant. For Phases III and IV, equipment installation will begin in the middle of Year 9 and proceed to completion of the full-size plant in the middle of Year 12.

3.19.5.4. Mine Shaft Excavation

Two access shafts will be sunk during the last half of Year 2. One of these mine shafts will be enlarged and another one sunk during Phase II. Twelve additional shafts may be sunk during Phases III and IV. The estimated 250,000 cubic yards of earth and rock removed for these shafts will be used as fill when it is of suitable quality. The remainder will be dumped in the processed shale area or stockpiled for revegetation, depending upon its quality.

3.19.6 CONSTRUCTION POLLUTION CONTROL

An environmental protection program has been designed to minimize detrimental environmental effects during site preparation and plant construction. This program includes control measures for noise and fugitive dust from various construction activities, proper disposal of solid wastes, control of erosion and runoff, and treatment and disposal of wastewater.

3.19.6.1 Fugitive Dust Control

During construction, fugitive dust will arise from activities such as the operation of heavy equipment, blasting, truck traffic, and operation of the concrete batch plant. To prevent fugitive dust from becoming airborne, the following steps are to be taken:

- Areas regularly traversed by heavy equipment will be dampened frequently and in some cases graveled or oiled.
- Wherever feasible, areas will be landscaped to minimize wind erosion.
- Main roadways and parking lots will be paved and maintained.
- Whenever feasible, blasting will be done in a manner that generates a minimum amount of dust.
- In the dumping and loading areas of the concrete batching plant, conveyors and elevators will be enclosed. Storage bin vents will have dust removal devices, and, wherever applicable, water spray will be used for dust control.

3.19.6.2 Construction Wastes (Solid Waste)

Construction debris — such as lumber, packing material, scrap metal, rubber, asphalt products, broken concrete, and other construction-related solid waste — will be collected and disposed of in the processed shale disposal site. The collection and disposal methods are discussed in detail in Sections 4.3 and 3.11.

3.19.6.3 Construction Liquid Wastes

Liquid wastes from construction activity will include dirty lubricant oil, sanitary wastewater, pipe test and flushing water, and construction-related liquid chemical waste.

Waste lubricant oil from construction equipment and vehicles will be deposited in a central collection tank for salvage and subsequent removal to an offsite location for proper disposal.

During the initial phase of construction, chemical toilets will be provided and serviced by a contractor. These toilets will not use an external water supply, nor will they discharge any liquids or solids on site. Upon completion of the sanitary wastewater treatment plant, toilets (temporary and permanent) will be connected to the plant for the convenience of the construction crew. In outlying areas, provision of chemical toilets will continue.

As plant piping systems are completed, they will be cleaned and tested by water flushing. This water will be collected and reused.

3.19.6.4 Sedimentation and Water Pollution Control

The problems of sedimentation and water pollution by silty storm runoff exist in most major construction projects. In site planning and preparation, WRSP will consider many measures to minimize the problem. Some of these control measures are discussed in the following paragraphs.

- A catch basin (actually two separate holding ponds) will be one of the first facilities constructed. Located at the north edge of the process area, it will be sized to collect the 100-year storm runoff from the entire process and shale stockpile area. In addition, the volume of this basin will be designed to hold a 10 percent sediment load.

  The collected storm runoff will be stored and used for dust control and other general construction purposes, During plant operation, the catch basin will collect storm runoff and treated wastewater.

- Upon completion of construction activities, the laydown areas, spoil areas, temporary parking areas, and temporary roads and haulways that are not required for the permanent facility will be landscaped to be compatible with the original terrain.

- Most of the disturbed areas, such as drainage ways, cut-and-fill slopes, borrow pit areas, and excavation and soil stockpiles, will be stabilized as soon as possible as part of a total grading and vegetation program. Runoff will be intercepted and diverted wherever such erosion protection is needed.
- Two impoundments will contain contaminants from the processed shale. The first will be the single retort phase dam; the second will be the Southam Canyon retention dam, as discussed in Section 3.10.

3.19.6.5 Construction Noise Control

The amount of noise generated by the construction activities will depend largely on the day-to-day schedules and the variations in equipment operation, weather conditions, etc. A preliminary evaluation was made of the construction noise level, and the results are discussed in Section 5.3

Section 3.20

Section 3.20

OPERATIONS MANPOWER

A pool of operations manpower will serve mining, retorting, upgrading, and all of the support functions necessary to the project as it moves through all phases to full commercial operations.

Since mine development is a steadily continuing activity, the mining manpower grows smoothly through all project phases until it levels off at 1,060 men at full production.

In contrast, the manpower requirements for Phases II, III, and IV pass through a peak at Phase II, decrease at the shutdown of Phase II operations, and then rise steadily into Phases III and IV to a final level requirement of 990 men at full production.

The buildup of operations manpower is summarized in Table 3.20-1, which shows the requirements at the end of each 6-month interval.

The relationship of this buildup of manpower requirement to the construction schedule is shown in Figure 3.19-2 in the preceding section.

Table 3.20-1

OPERATIONS MANPOWER REQUIREMENTS

Phases I and II		Phases III and IV	
Year	Number	Year	Number
2	10	8	–
	27		205
3	40	9	296
	60		395
4	96	10	604
	133		808
5	147	11	850
	161		1,190
6	324	12	1,650
	324		2,050
7	324	13	2,050
	324		2,050
8	308	14	2,050
	–		2,050 (a)

(a) After 1988, the requirement will remain level at 2,050 men.

Section 3.21

Section 3.21

DECOMMISSIONING-ABANDONMENT PLAN

Plans have been made to ensure that during decommissioning-abandonment the lease stipulations are followed, that the improvements are treated properly, and that the environment is protected.

The lease provides for lease relinquishment, remedies in case of default, delivery of premises in case of default, and disposition of property upon termination of the lease (Ref. 1). The plan described in this section is intended to comply with the lease provisions governing actions taken after suspension of operations or termination and relinquishment of the lease by either party.

- Decommissioning. This action could occur when the lessee elects to suspend operations for further processing of shale but anticipates resumption at a later date. For example, the lessee might proceed with decommissioning at the scheduled conclusion of the single retort operation phase in year 8. Decommissioning could also occur with the owners retaining the lease or, under conditions of relinquishment of the lease, with sale of all or part of the improvements to others.
- Abandonment. This action would occur when the lease is relinquished or terminated without sale of the permanent improvements to others. Circumstances causing abandonment would be either exhaustion of the reserve (lack of sufficient raw material for economic mining and processing) or economic or technological problems that would dictate conclusion of operations either after decommissioning of the single retort phase or during the commercial operation.

3.21.1 DECOMMISSIONING

This subsection describes decommissioning plans for the leased land and its improvements. These plans will be implemented under circumstances described above.

3.21.1.1 Preservation of the Mine and Aboveground Facilities

The mine will be maintained on a standby basis, which includes pumping to keep the mine dewatered. Mining equipment will be mothballed and stored, and mine structures and openings will be periodically inspected and maintained.

All aboveground improvements will be maintained for future recommissioning. Vessels will be cleaned out and degassed; catalysts and chemicals will be removed and stored or disposed; and equipment will be mothballed in place or stored, as necessary, using protection techniques appropriate to the expected downtime period. Inventories of products will be shipped or secured.

3.21.1.2 Maintenance of Processed Shale Disposal Area, Retention Dam, and Reservoirs

Maintenance of the processed shale disposal area, retention dikes, dams, and reservoirs will continue through the period when facilities are decommissioned. Programs of stabilization, erosion protection, drainage, and revegetation of the processed shale disposal area will proceed to realize objectives.

Wastewater and emergency runoff holding basins will be drained at decommissioning and attended thereafter as long as practical. To provide supply of fresh water and to furnish fire protection, the freshwater reservoir will continue to function at a reduced level after decommissioning.

3.21.1.3 Manpower

Decommissioning after Phase II will result in displacement or reassignment of certain personnel. After shutdown of the Phase II facilities, mine development will continue. The retort operating and maintenance personnel will be employed in construction of the commercial plant.

Decommissioning under other circumstances will result in reassignment of manpower. If the operation is expected to be resumed shortly, personnel will be retained. Personnel will be kept to service the ongoing responsibilities such as retention dam, revegetation plot, etc., as required.

3.21.2 ABANDONMENT

Abandonment of Leases U-a and U-b will follow the conditions established in the shale oil leases. The abandonment plan will be initiated by the White River Shale Project under circumstances described above.

3.21.2.1 Return to a Natural State

The disturbed areas are to be restored as closely as possible to their natural state. After removal of all salvageable equipment, the shafts and mine portals will be sealed and the mine allowed to fill with water. All surface equipment and structures will be removed and the foundations taken down to grade. Disturbed areas will then be rehabilitated and revegetated to conform to aesthetic provisions of the lease as described in Subsection 4.6.1.

3.21.2.2 Maintenance of Processed Shale Disposal Area, Retention Dam, and Reservoirs

These programs and facilities will be continued to minimize any adverse environmental effects and to comply with approved plans and lease terms. Subsection 4.6.2 discusses the revegetation plans for processed shale. If abandonment occurs before commercial operations, the Phase II retention dam will be raised by 5 feet to control runoff.

3.21.2.3 Manpower

The work force will be reduced gradually by relocation or termination of personnel. After abandonment has been completed, a minimum work force will be retained to deal with any residual facilities or programs requiring attention.

GLOSSARY

Abandonment. A relinquishment or a termination of the lease and no sale to another party of the permanent improvements.

Acid gas. The hydrogen sulfide and carbon dioxide found in natural and refinery gases which, when combined with moisutre, form corrosive acids; these are known as sour acids when hydrogen sulfide or mercaptans are present.

Acre-foot. The volume of water that can cover one acre to the depth of one foot (325,850 gallons). One acre-foot per year equals 0.62 gallon per minute.

Alluvium. Clay, silt, sand, gravel, or similar detrital material deposited by running water.

Amine. One of a class of organic compounds which can be considered to be derived from ammonia by replacement of one or more hydrogen atoms by organic radicals.

Amine gas-treating unit. A unit that absorbs and removes acid gas from product gas by contacting the product gas with an aqueous solution of amine.

AOSO. Area Oil Shale Office.

AOSS. Area Oil Shale Supervisor.

Aquifer. A water-bearing stratum of permeable rock, sand, or gravel.

AUM. Animal unit month. The amount of forage on an acre of land required to support one cow or five sheep for one month.

Baseline environmental data. Data on Tracts U-a and U-b developed WRSP. This information is summarized in Part 2 and in the First Year Annual Baseline Report prepared VTN (see "baseline environmental data").

Bbl. Barrels.

Berm. A narrow shelf, path, or ledge typically at the top or bottom of a slope.

Biota. The collective flora and fauna of any particular area.

BPCD. Barrels per calendar day (one barrel = 42 gallons; a calendar day includes downtime).

BPSD. Barrels per stream day.

Bottoms. Oil, water, and foreign matter that collect in the bottom of storage tanks.

Btu. British thermal unit, a unit of energy.

C_5+ refined shale oil. Pentane and heavier shale oil.

Catalytic converter. A cracker that uses catalysts.

Catalytic cracking. Conversion of high-boiling-point (high molecular weight) hydrocarbons into lower-boiling-point (lower molecular weight) types by heating the hydrocarbons in the presence of a catalyst.

Catchment. (See "single retort phase dam.")

Centroid. (See "oil shale deposit centroid.")

Claus sulfur plant. A plant that converts hydrogen sulfide in a gas stream into elemental sulfur by means of solid catalysts.

Coke. A coherent, cellular, solid residue remaining from the dry (destructive) distillation of a coking coal, petroleum, or other carbonaceous material.

Coking. Destructive distillation of coal to make coke; a process for thermally converting the heavy residual bottoms of crude oil entirely to lower-boiling-point petroleum products and by-product petroleum coke (thermal cracking for the conversion of heavy, low-grade oils into lighter products and a residue of coke).

Commercial Operation Phases. (See "Phase III" and Phase IV.")

Cracking. Conversion of high-boiling-point (high molecular weight) hydrocarbons into lower-boiling-point (lower molecular weight) hydrocarbons.

Crude shale oil. The oil produced by heating oil shale in a retort.

CS. Centistokes, a unit of viscosity.

Cut-and-fill. A process for leveling land (to build roads, etc.) in which higher elevation land is removed and placed in lower elevation land to create a flat surface.

dB. Decibel.

dBA. Decibel (acoustic).

Decibel. A unit for measuring the relative loudness of sounds and approximately equal to the smallest degree of different of loudness ordinarily detectable by the human ear. The range includes about 130 decibels on a scale beginning with 1 for the faintest audible sound.

Decommissioning. The suspension by the lessee of the work programs or the further processing of shale, without dismantling or destroying improvements.

DDP. Detailed Development Plan.

DH. Direct heated.

Direct heated mode. A method of imparting heat to the shale, whereby fuel and oxygen are injected into the retort for combustion and direct contact heat transfer.

Drainage basin. The entire tract of country drained by a river and its tributaries.

Feed. Raw material that is fed into and processed in a unit.

Feed gas. Gas that is fed into and processed in a unit.

Fines. Smaller particles of oil shale coming out of the mine, or from the crushing operation. Fines are generally pea-sized and smaller (1/2-inch and under) and must be removed from the feed of certain retort systems.

Fischer assay. A standard laboratory method for determining the amount of oil in shale. The results are expressed as gallons of oil per ton of oil shale.

First-train operation. Commercial operation during Phase III.

Flue gas. The waste product of the combustion of fuel in the heater of an IH retorting system.

Forb. An herb other than grass.

Fugitive dust. Colloidal-sized particulate matter generated incidentally by man's activities.

Gas treating. Removing nonhydrocarbon impurities (such as water vapor, hydrogen sulfide, or carbon dioxide) from product gas.

Gilsonite. A black lustrous asphalt occurring especially in Utah (trademark).

GPT. Gallons per ton.

gr/SCF. Grains per standard cubic foot.

HHV. High heating value.

High-Btu gas. A high heating value gas. The product gas from IH retorting is a high-Btu gas.

Holding basin. (See "wastewater and storm runoff holding basin.")

HTU. Hydrotreating unit.

Hundred-year flood. The maximum flood that can be expected in a 100-year period.

Hydrocarbon. An organic compound containing only carbon and hydrogen.

Hydrotreating. An oil refinery catalytic process in which hydrogen is contacted with petroleum intermediates or product streams to remove impurities, such as oxygen, sulfur, nitrogen, or unsaturated hydrocarbons.

Hydrostabilization. A mild hydrotreating process that uses less hydrogen than hydrotreating.

IH. Indirect heated.

Indirect heated mode. A method of imparting heat to the shale by an externally heated circulating gas stream.

In situ. Derived from the Latin term meaning "in place." With reference to oil shale, it describes a method of underground retorting whereby the oil is recovered and the shale residue is left in the ground.

Kerogen. The organic portion of oil shale. It is a hydrocarbon that breaks down when heated (to about 900° F) to form a synthetic oil.

kV. Kilovolts (1,000 volts).

kW. Kilowatts (1,000 watts).

Leachate. A solution or product obtained by leaching.

Light ends. The lower-boiling-point components of a mixture of hydrocarbons, such as those evaporated or distilled off easily in comparison with the bulk of the mixture; for hydrocarbon mixtures, this is usually considered to be butane or lighter.

Low-Btu gas. A gas with a low heating value. The product gas from DH retorting is a low-Btu gas.

Marlstone. A rock consisting of approximately equal amounts of carbonate and clay. Oil shale is basically a marlstone.

Mining panel. In the room and pillar method, a large area in the mine in which many pillars are left to support the roof.

MMM. Billion.

MW. Megawatts (one million watts).

Nahcolite. The mineral sodium bicarbonate. It is potentially commercially valuable for removing sulfur from flue gases.

Naphtha. (See "petroleum naphtha.")

Oil Shale. Laminated sedimentary rock deposits containing both mineral and organic matter, principally kerogen.

Oil shale deposit centroid. The center of mass of the oil shale, as determined by geological studies.

Oolitic. The quality of having small round bodies that have grown by external accumulation. Usually refers to a sedimentary rock.

OSEAP. Oil Shale Environmental Advisory Panel.

Overburden. Nonresource-bearing strata overlying the oil shale.

Panel. (See "mining panel.")

Paraho. A retorting method, either DH or IH, in which minus 3-inch plus 1/2-inch shale is processed in a vertical kiln retort.

Particulates. Solid materials generated by processes and emitted from a discrete source (see "fugitive dust").

Petroleum naphtha. A generic term applied to refined, partly refined, or unrefined petroleum products and liquid products of natural gas.

Phase I. The initial mine access phase.

Phase II. The phase during which a single commercial sized retort, along with working mine and ancillary facilities, is developed.

Phase III. The first of two commercial operation phases, culminating in single-train operation.

Phase IV. The second of two commercial operation phases, culminating in full-scale two-train operation.

Portal. The surface entrance to a drift, tunnel, adit, or entry.

Pour point. The lowest temperature (determined by laboratory procedure) at which a liquid hydrocarbon will remain fluid enough to be poured.

Pour point depressant. An additive that lowers the pour point of a wax-containing petroleum-base lubricating oil by reducing the tendency of a wax to solidify.

Processed shale. The residue shale from the retorting operation. It is normally 80 to 85 percent the weight of the original oil shale material.

Product gas. The gas emitted from the DH or IH retort during the retorting of shale oil.

Pyrolysis. Chemical change brought about by the action of heat.

Reforming. The thermal or catalytic conversion of petroleum naphtha into more volatile products of higher octane number; represents the total effect of numerous simultaneous reactions, such as cracking, polymerization, dehydration, and isomerization.

Reforming catalyst. A catalyst used in a reformer.

Retort. A vessel through which the oil shale passes and the retorting process is carried out.

Retorting. The process in which the kerogen in oil shale is converted by heating to an oil.

Room and pillar. An underground mining technique in which a room is mined out and a pillar is left for mine support.

Room. The opening in a mine between pillars.

SCFCD. Standard cubic feet per calendar day (SCF measured at $60^{o}F$ and 1 atmosphere).

SCFM. Standard cubic feet per minute.

SCFSD. Standard cubic feet per stream day (stream day does not include downtime).

Scrubber. (See "wet scrubber.")

Shale Oil. A black, tarry liquid product produced from the retorting operation.

Single retort operation. (See "Phase II.")

Single retort phase dam (catchment). A dam built during Phase II adjacent to the processed shale pile, the purpose of which is to intercept runoff and leachate from the single retort processed shale pile.

Slurry. A watery mixture of insoluble matter.

Sour gas. A gas mixture that contains hydrogen sulfide or mercaptans.

Sour water. Water containing hydrogen sulfide or mercaptans.

Sour water stripping. Removing hydrogen sulfide from sour water.

Southam Canyon retention dam. A dam built during Phase III at the mouth of Southam Canyon, the purpose of which is to intercept processed shale runoff and leachate and hence prevent them from reaching the White River.

Stope. An underground excavation from which the ore has been extracted, in a series of steps.

Storage silo. A circular vessel, usually having a conical bottom section, that is used for storing solids in bulk quantities.

Stretford sulfur unit. A plant that converts hydrogen sulfide in a gas stream into elemental sulfur by using a catalyst in a liquid medium.

Surge bin. A storage vessel that holds a sufficient volume of material to provide a steady supply to a downstream user or process.

Tail gas. Waste gas from a sulfur-treating plant.

Tail gas treating. Removing sulfur from tail gas.

Tank farm. An area containing large storage tanks for oil or other liquids.

TBP. True boiling point.

TDS. Total dissolved solids.

TOSCO. A retorting method, in which minus 1/2-shale is processed in an IH retort.

TPCD. Tons per calendar day.

TPD. Tons per day.

Train. A processing system comprising a series of processing units.

Transect. A sample area (as of vegetation), usually in the form of a long continuous strip.

Tuff. A rock composed of the finer kinds of volcanic detritus, usually fused together by heat.

Turndown ratio. A measure of a unit's ability to operate at lower rates.

Two trains. Two parallel processing systems.

Upgrading. The various process combinations employed to improve the quality of the oil.

Vector. Any organism that is the carrier of a disease-producing virus or bacteria.

Visbreaking. A mild thermal cracking process that lowers the molecular weights of the hydrocarbon molecules only slightly.

VTN. A Denver-based company that specializes in engineering and environmental studies.

Water bar. A ridge built across a road to divert runoff.

Wet scrubber. A vessel in which spray liquid is used to absorb solid particles and remove them from circulating gases.

WEA. Western Environmental Associates.

WRSP. White River Shale Project.

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